Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

JANUARY 1949

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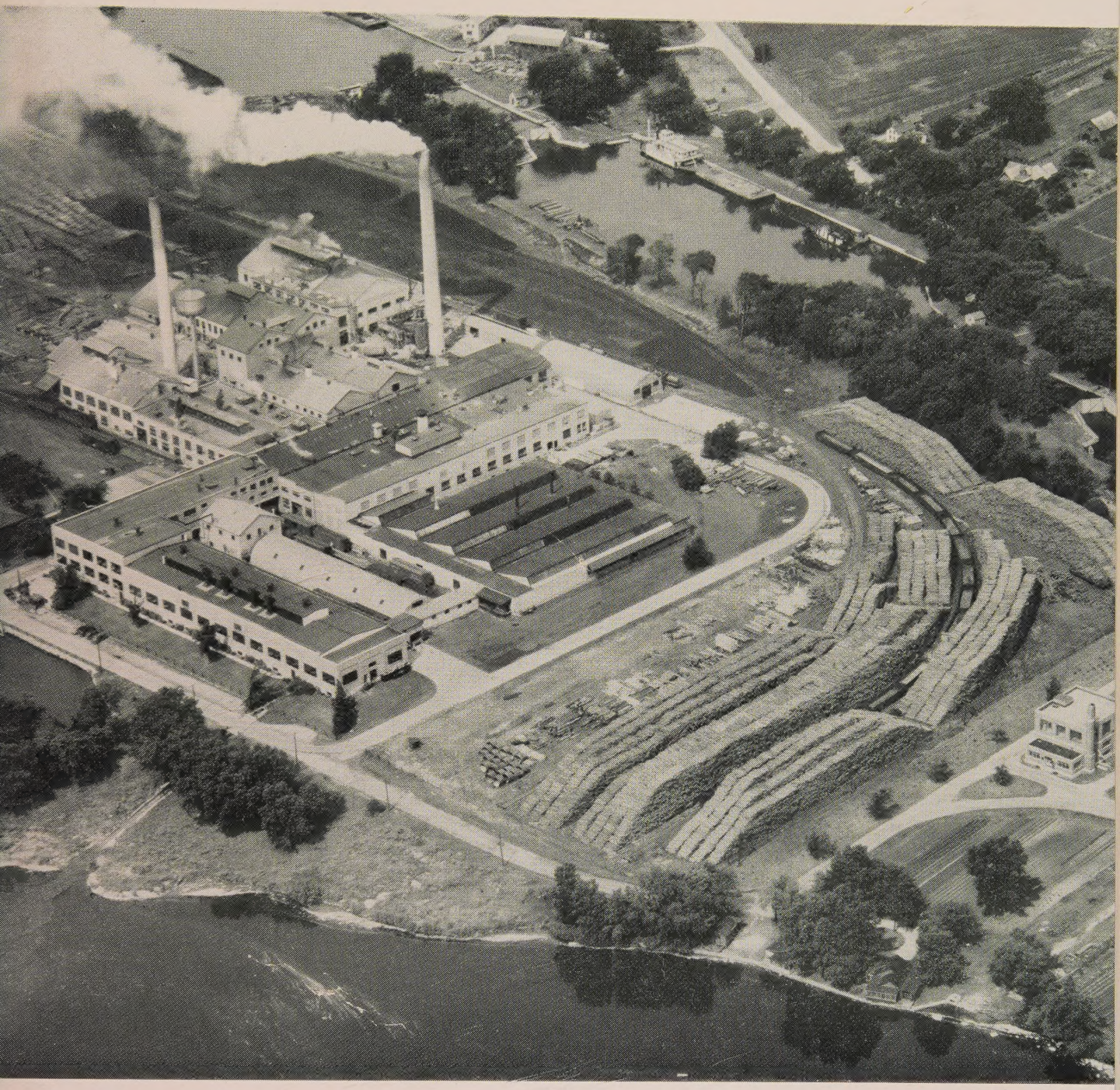
Thilmany: glassine and kraft specialties



One of the oldest manufacturers of glassine and kraft specialties is Thilmany Pulp and Paper Company, at Kaukauna, Wisconsin. In 1891, Thilmany bought the first Beloit Yankee machine ever built; it's still operating, along with a new Beloit machine installed in 1942. Just recently another Beloit machine was started up, the mill's No. 10 . . . Ever since 1858, when Beloit Iron Works was founded, industry leaders have looked to Beloit for the newest and best in paper machinery.—*Beloit Iron Works, Beloit, Wisconsin.*

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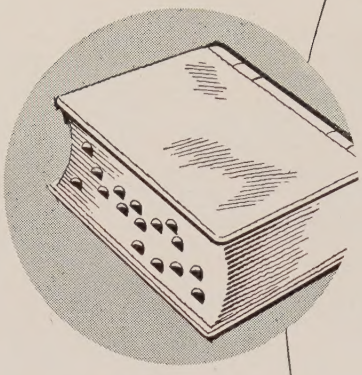

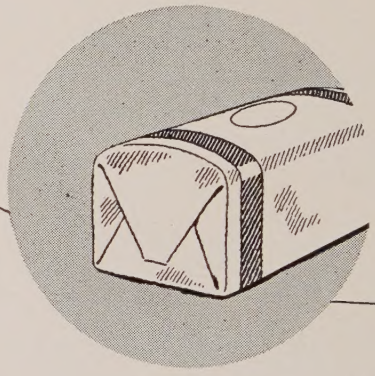

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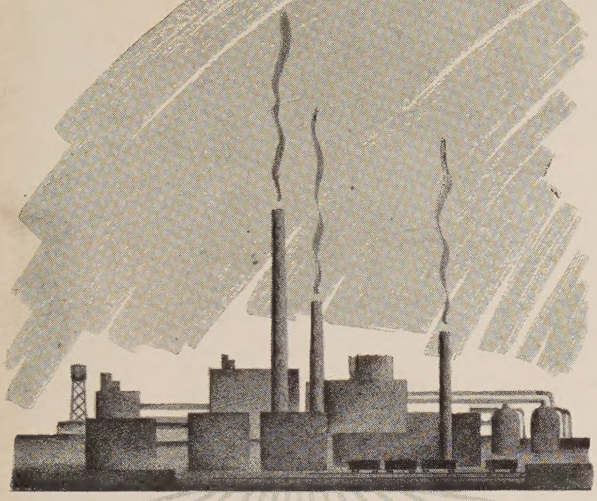

CHLORINE first began to be an important factor in the pulp and paper industry in the twentieth century. The basic procedure in pulp bleaching had already been established. As early as 1830 reference is made to its commercial use in Russia for bleaching straw and esparto. By 1847 chloride of lime had been substituted for chlorine water.

The rapid expansion of the pulp and paper industry coincided closely with the increase in the electrolytic manufacture of high quality chlorine. The cooperative research and experimentation of pulp and paper makers and chlorine producers were also potent factors in the development of superior bleaching processes. These led to the economical and large volume production of high quality papers. Hooker Electrochemical Company has been active in these developments, has contributed much to the techniques of pulp bleaching, and in the engineering "know how" that were so necessary to make these processes practical.

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JANUARY 1949

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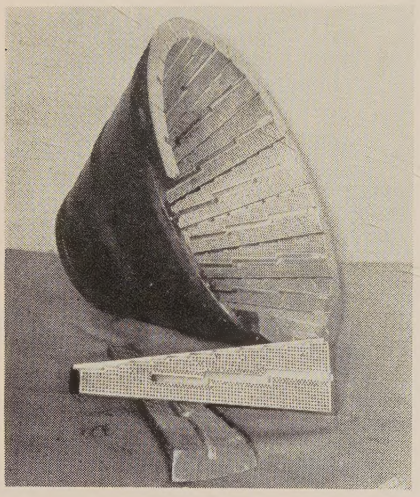
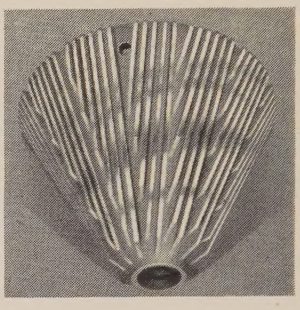


PLUG (7402)



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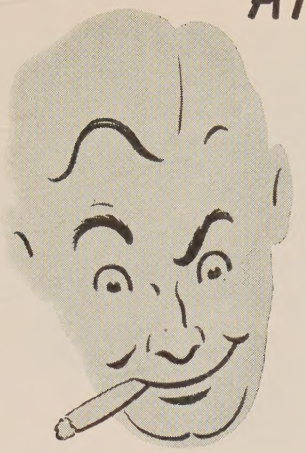

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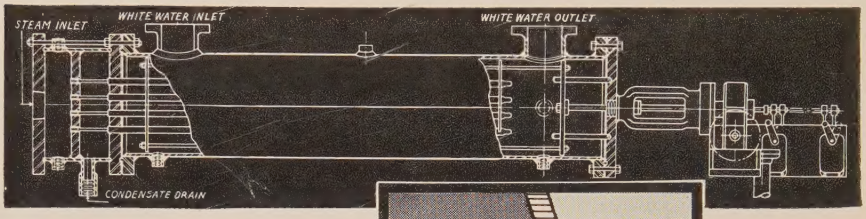
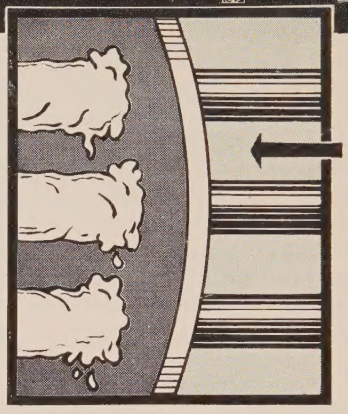


HOW IT WORKS

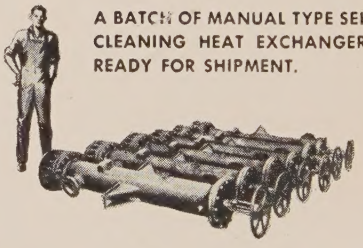
The transverse heater baffles, which also serve as tube surface cleaners, are connected by tie rods to the yoke plate, which in turn is connected to the drive mechanism at the right. The time controls close the motor circuit at predetermined intervals. The yoke plate moves each baffle longitudinally along the tubes, until the drive mechanism reverses the action and returns the baffles to their original position.

Available in models for either manual, electric motor or hydraulic piston drive. Automatic types operate on adjustable predetermined time schedules.



BAFFLES MOVE FORWARD AND BACKWARD LEAVING TUBES CLEAN AS A WHISTLE

Patent No. 1826747
Other Patents Applied For



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Every Inch of Every Tube Is Thoroughly Cleaned At Every Cycle!
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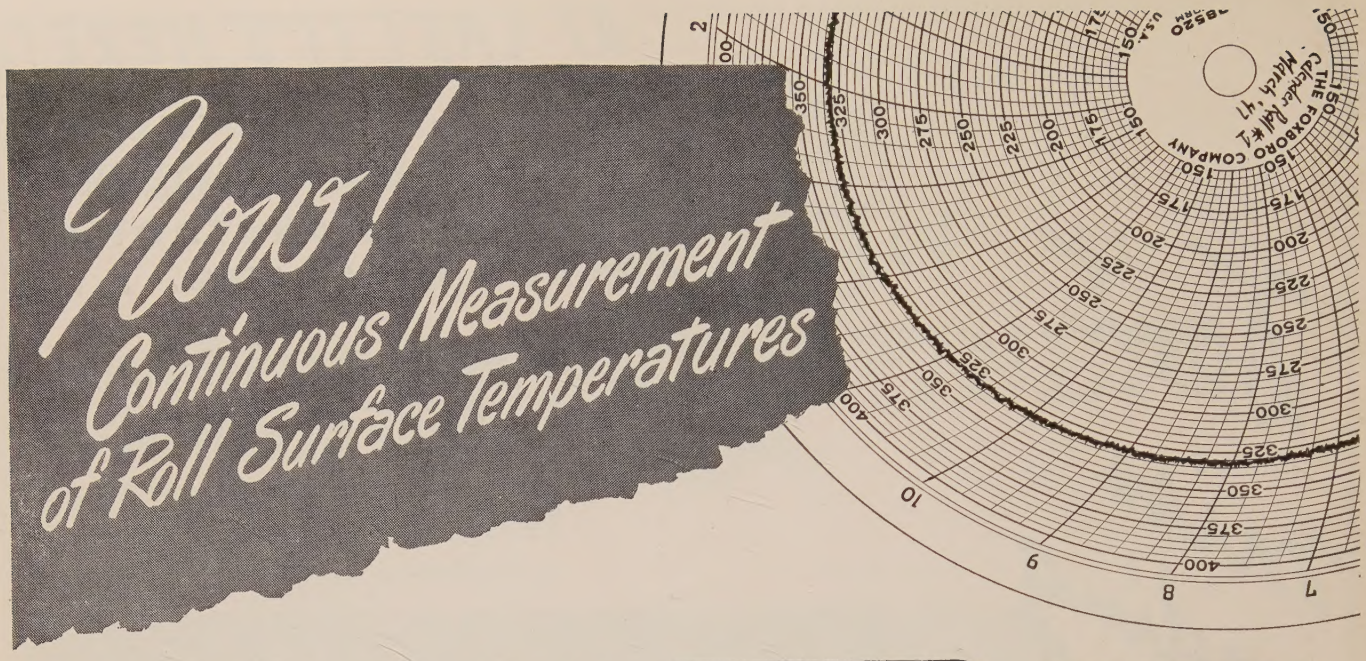

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AN ENTIRELY NEW type of measuring head coupled with the sensitive, instantly-responding Dynalog Electronic Recorder solves a tricky problem of long standing. This combination has proven far more accurate—and convenient—in the continuous measurement of roll surface temperature than previous devices.

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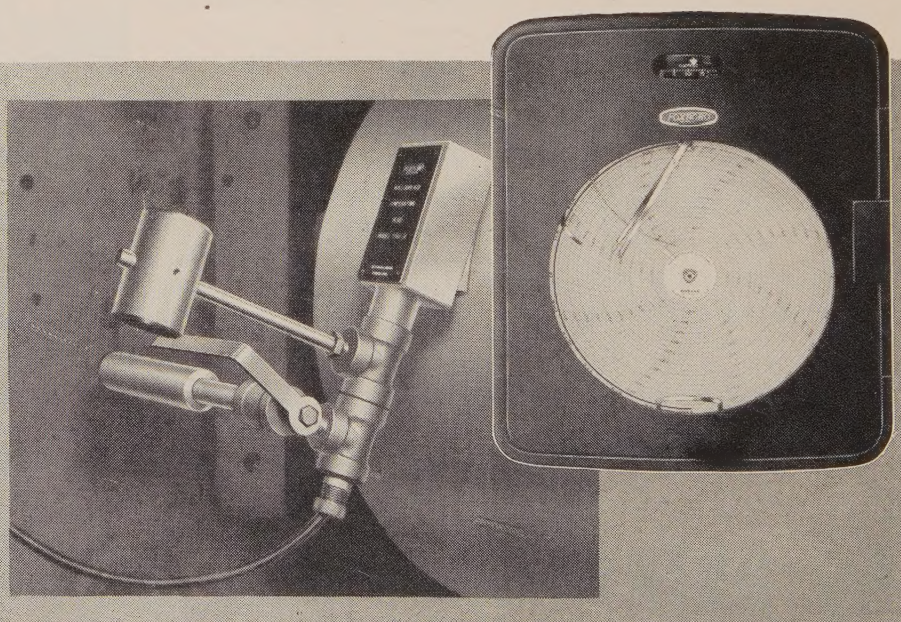
Using either a Dynalog Recorder or Controller, this is the system to install wherever closer, continuous measurement or control of roll surface temperatures means a saving in steam, a reduction in waste, a more uniform product. Get complete details—Bulletin 405. **The Foxboro Company, 78 Neponset Avenue, Foxboro, Mass., U. S. A.**



Foxboro Dynalog Controller at far right. Installation photo shows New Sensitive Element—basically, a miniature resistance bulb having highest sustained accuracy of any temperature measuring element within its range. Accuracy of readings is protected by complete isolation of element from ambient and radiant temperature effects. High speed response to roll surface temperature changes. Operating range: —40° F. to +350° F. or higher under special conditions.

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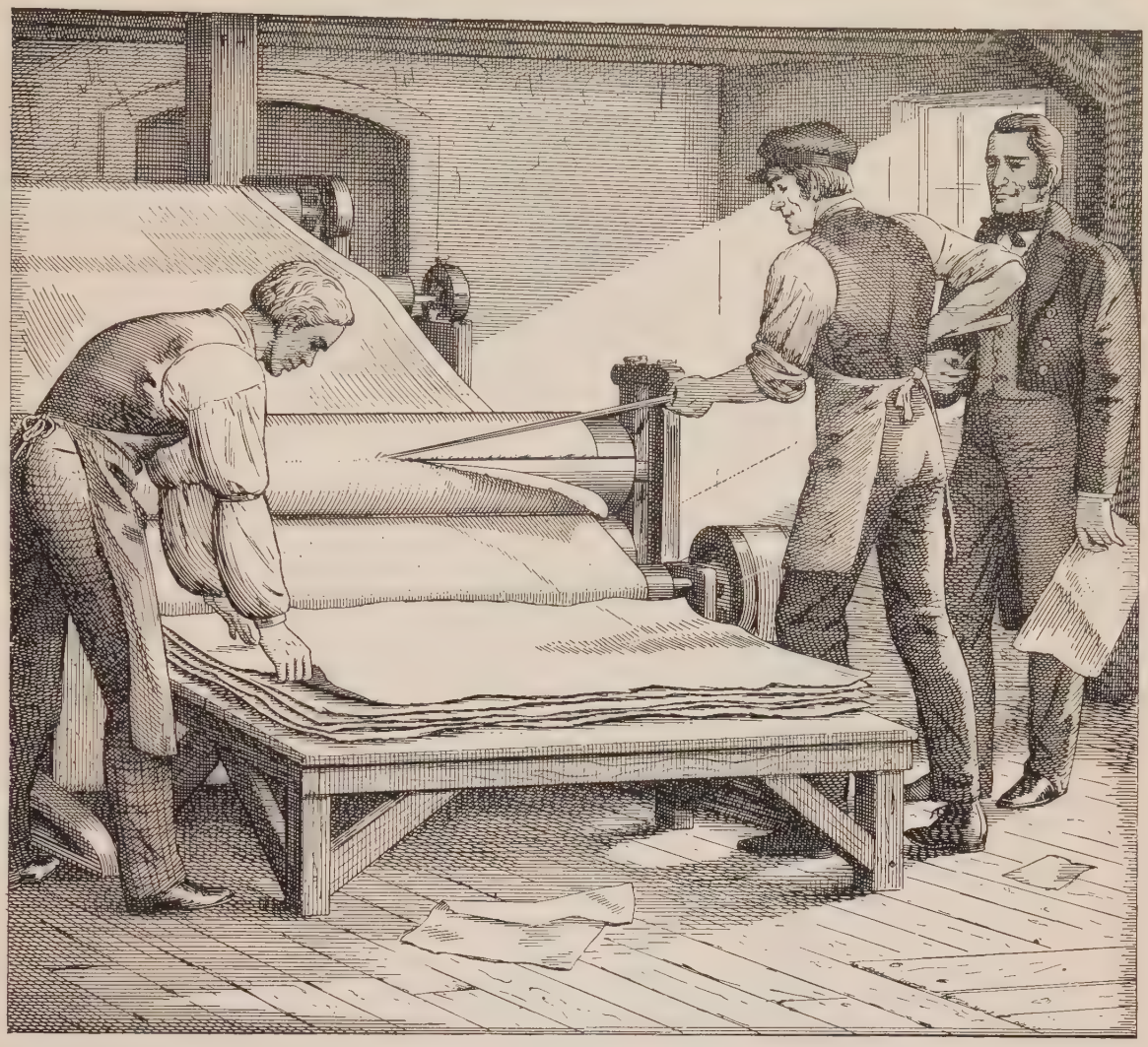

Here Began America's Paper-Board Industry

In 1828, G. A. Shryock, using a pulping process developed by William Magaw, began making wrapping paper from straw in his mill at Chambersburg, Pa. Soon he found that when the paper broke and several wet layers of pulp became wound around the cylinder they formed what he described as a "solid and beautiful binder's board." "Many predicted," he wrote years later, "that these boards would become one of the indispensable products of the world; others said they were not worth as much as the stones in the street."

How right were the former, how wrong the latter, history has long since proved. The boards made in this mill were not only the first successfully made from straw, but they marked the beginning of the vast and essential American paper-board industry of today.

The dramatic story of paper is told in the sound-and-color film, "Paper — Pacemaker of Progress," and in a book under the same title. Both are presented by F. C. Huyck & Sons as a tribute to the Paper Industry. The book will be sent free upon request

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The Three Musketeers

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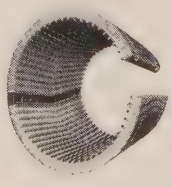
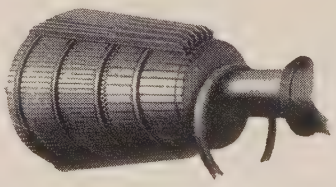
Today their counterpart really "lives" in industry — Miami Jordan, Bulldog filling and X-66 Plug — the "Three Musketeers" of papermaking—another famous team.

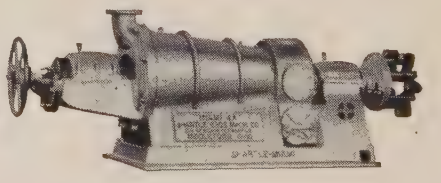
Evidence of the fact is the recent installation of six Miami No. 5's at Michigan Carton and the Bulldog and X-66 Plugs that make them "tick."



BULLDOG FILLING for all ages, makes, models and sizes of Jordans.



X-66 PLUGS to fit all needs.



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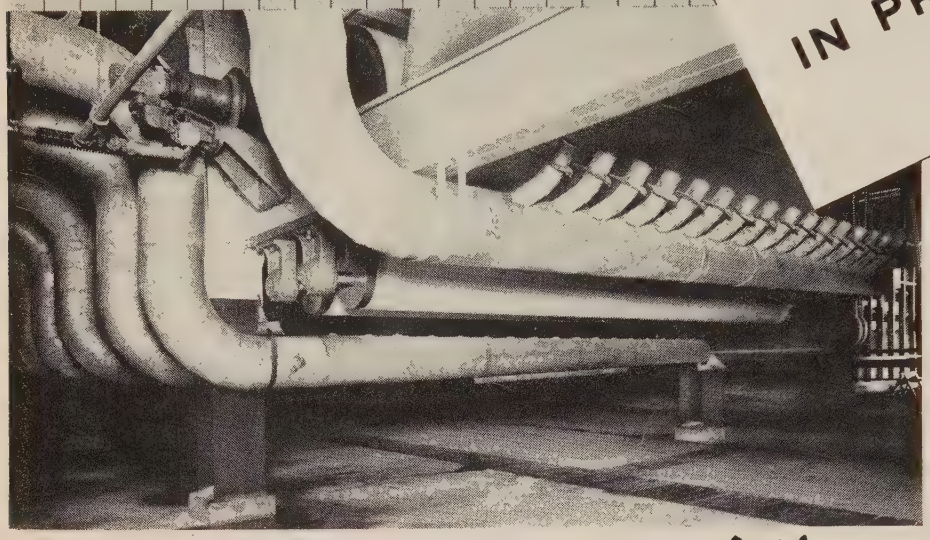

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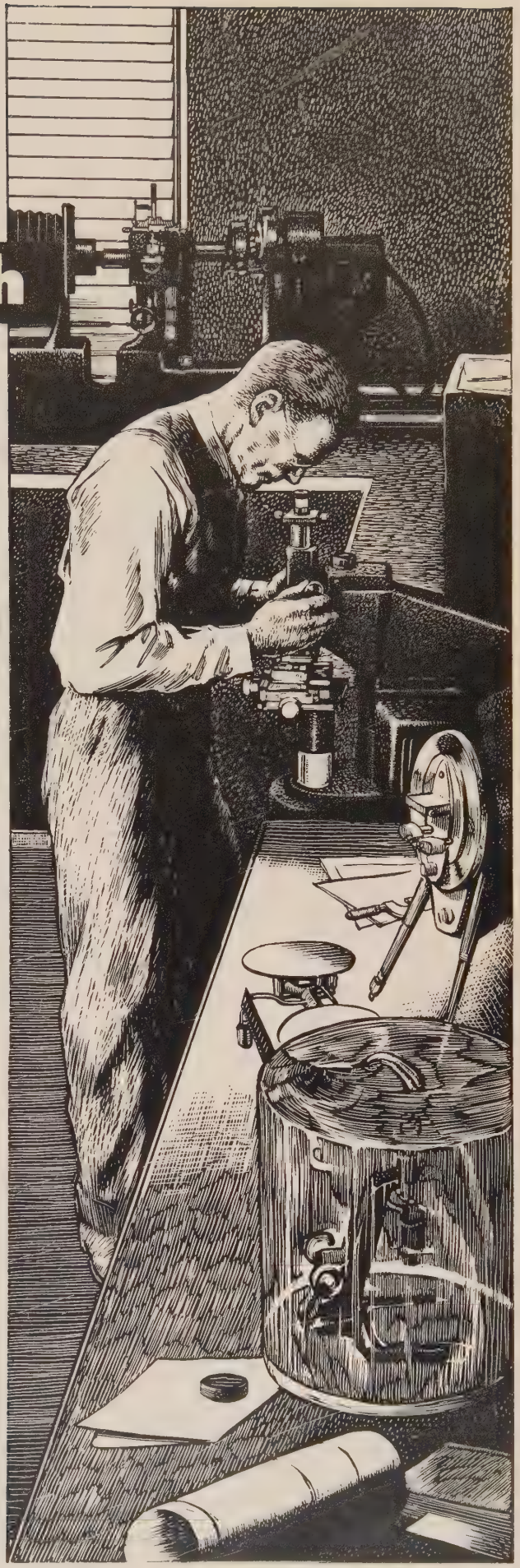

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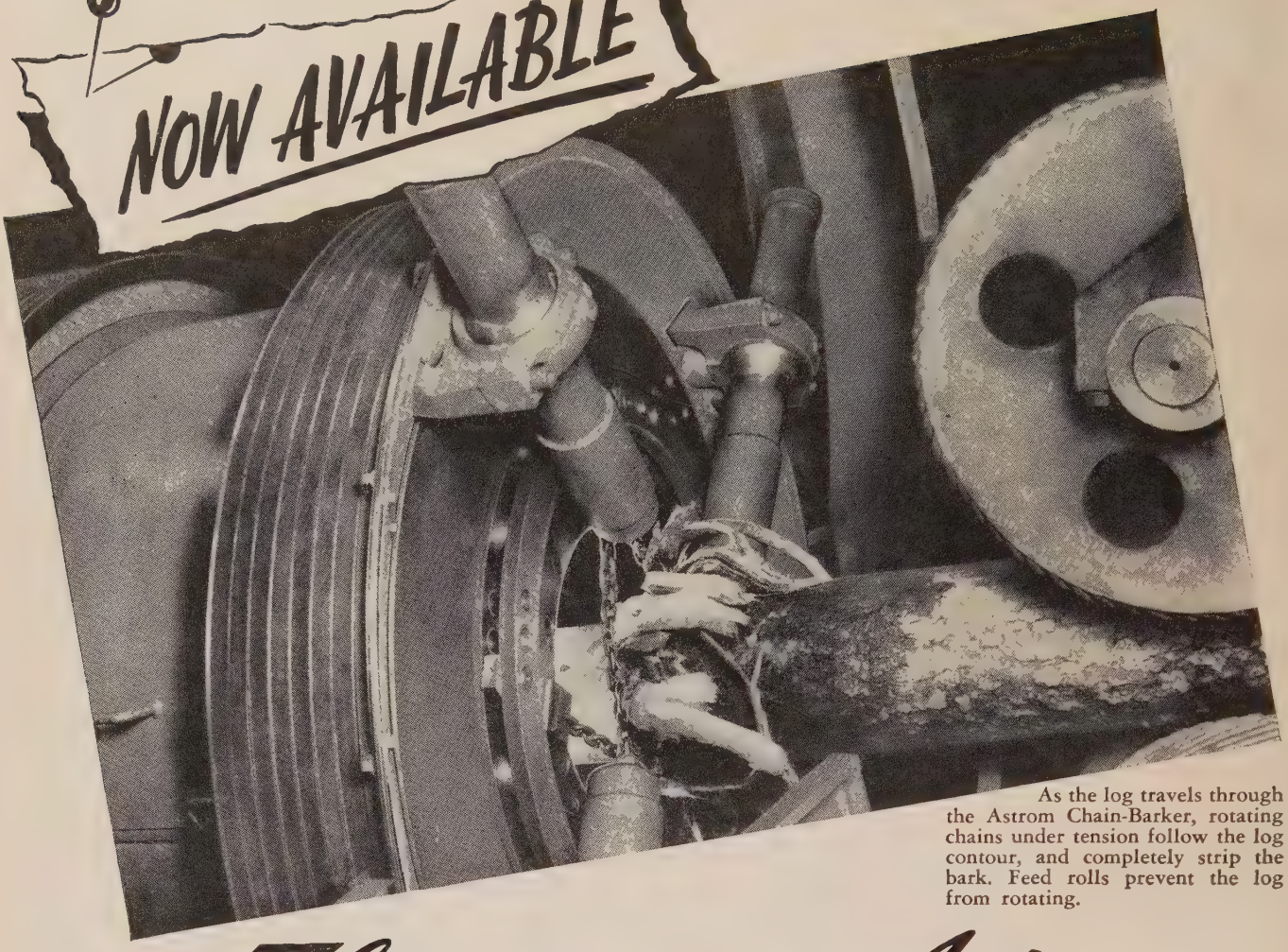

As the log travels through the Astrom Chain-Barker, rotating chains under tension follow the log contour, and completely strip the bark. Feed rolls prevent the log from rotating.

The AMERICAN Astrom CHAIN-BARKER

SPECIFICATIONS

Size of log—Handles logs from 4″ to 15″ of any length. Most economical with lengths 10′ and up.
Capacity—6 to 15 cords per hr. depending on log condition.
Power consumption—As low as 4 kwh per cord.
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Weight — Approximately 11 tons. Can be transported as a unit without disassembly.

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- **High capacity**
- **One-man pushbutton operation**
- **Portability**

The present Astrom Chain-Barker is especially suitable for pulp wood operations, and can be transported from location to location as a unit.

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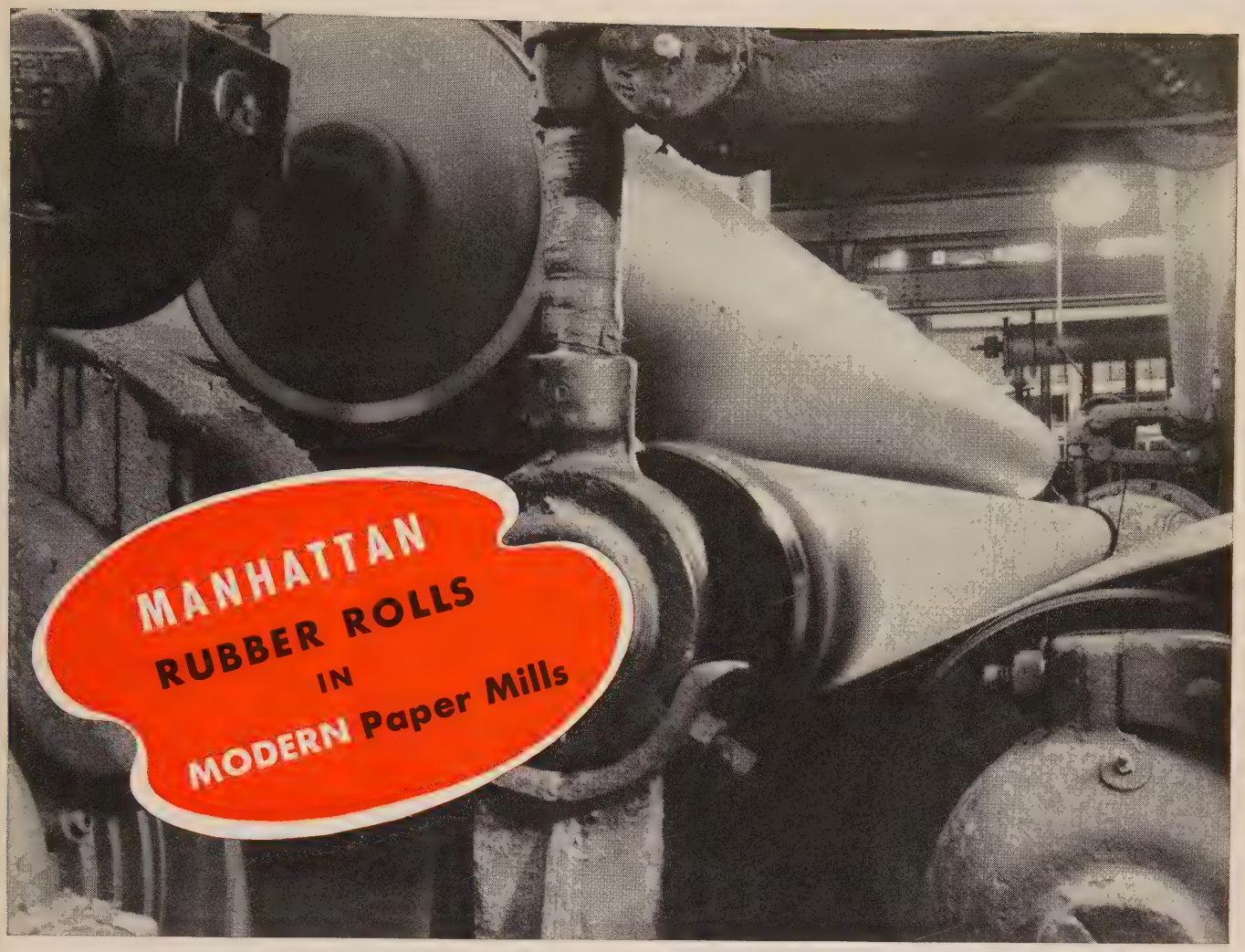

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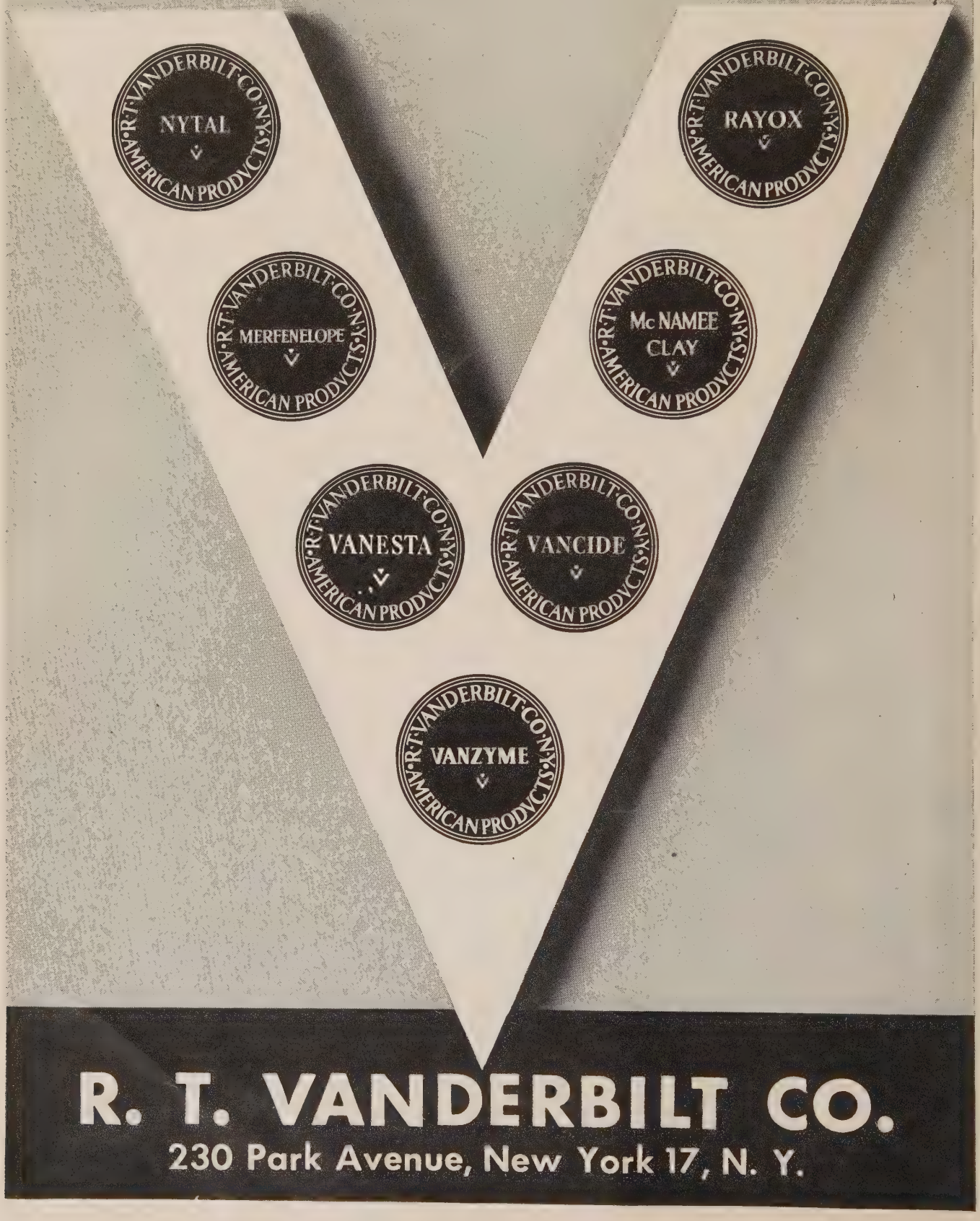

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The PRESIDENT'S PAGE

For several years a considerable part of our membership has felt that the Technical Association should have its own official publication. During this period much study has been given to the possibility, by the Executive Committees, by specially appointed committees, and by your Secretary. At the Executive Committee meeting, February, 1948, the decision was made that we should start our own journal in January, 1949. With this issue the wish of many of our members has been fulfilled.

Several good reasons for this publication can be advanced. Only one can justify it. The quality of the literature on the many phases of pulp and paper technology can be improved and it shall be the main objective of *Tappi* to accomplish this. *Tappi* will be a balanced presentation of the science of our industry. It will attempt to appeal to our membership as a whole but always deal with facts. Quality is our watchword.

To accomplish this there are many obligations to be met. Members of the Association have asked for their own magazine; they must support it with the reports of their investigations, where company policy permits. Without such support the high ideals we have set are not attainable. Committees have an obligation. They represent the true cross section of Association interests. It is a responsibility they must accept to see that the interests of their groups are well reported in *Tappi*. On the shoulders of the Executive Committee must rest the responsibility of providing adequate editorial and business management.

It would be too much to expect that this, our first issue, meets all your desires. This is a new field for the Technical Association. We have much to learn in providing you with what you wish. So we ask your forbearance in our mistakes as we ask for your criticisms in correcting them.

As you look through these pages one of the reasons this publication is possible will be obvious. Over the past years the Association has been supported by its sustaining members in a whole-hearted and friendly manner. We are appreciative of this loyal support and have tried our best to justify it. In this new venture they have again shown their confidence in us. To our friendly advertisers we are truly thankful.

Another reason this publication has become a reality is not so obvious. Only a very few, who may be familiar with publication problems, can have a real appreciation of the multitude of details that must be handled in a project of this kind. To have accomplished so much in a period of so few months reflects long hours of concentrated effort in addition to the normal duties of our staff. Throughout these months our secretary, Ronald G. Macdonald, has served us with leadership, patience, judgment, and energy. Those of us who have been associated with him in a small way during the studies that have been necessary, know well that without such leadership our venture might not yet be ready to launch. It is my privilege, on your behalf, to recognize this leadership.

In *Tappi* another milestone has been passed. It will increase our range of services to our members. It will assist us "in our search for and dissemination of knowledge relating to the paper industry." Our goal becomes a little closer, our ambitions are nearer realization. With our members' continued cooperation this step may well be the most important we have ever taken.

W. F. Gillespie
President of TAPPI

EDITORIAL *Tappi* COMMENT

A New Magazine Ventures Forth

The present issue of *Tappi* adds another publication to the pulp and papermaking literature. It differs from the many that have become well known in that it is a professional journal rather than a trade paper. The industry is well supplied with the latter which, in addition to serving their primary function of publishing current news, have also attempted to serve the professional field as well.

Since 1921 the Technical Association has published most of its meeting papers and contributed articles in one of these trade papers, the *Paper Trade Journal.* Many of its papers have also appeared in the other magazines serving the industry. For several years a number of members have urged the Association to publish its papers in its own technical journal. It was felt that the Association had acquired sufficient size and strength to conform to the practices of such other professional organizations as the A.S.M.E., A.C.S., A.I.Ch.E., A.S.C.E., and other well-known engineering societies.

It was further felt that such a magazine devoted entirely to the manufacturing problems of mill-operating executives, engineers, superintendents, chemists, and other technical men could do much to advance the industry along the technical lines that are vital to its existence and progress.

The problems involved in creating a new magazine of this type were by no means minor ones. In times of rising prices the problem of financing is one of considerable magnitude. The advertisers in this issue and those to appear in subsequent issues have helped greatly. With most printing plants overcrowded with magazines the Association may consider itself fortunate in obtaining the services of the Mack Printing Company, one of the leading printers of technical magazines.

Every effort has been made to provide a good-appearing publication. This was not as easy as it might seem and much still needs to be done to attain the desired objective. However, the heart of this publication is its technical papers and they are of a high quality and worthy of permanent record.

The future standing of *Tappi* depends mostly on the initiative and willingness of each individual member to share his knowledge with his fellow members, not only at Association meetings but throughout the year. A good job has been done to date and undoubtedly will be done in the future. In fact, past experience would indicate that this issue and those to follow this year will attain the stature of collector's items in a few years. Many volumes of Technical Association Papers are in this category. We would advise all recipients of these issues to retain them. They will have a ready market for years to come for those who may wish later to dispose of them.

Volume 32

Some may express surprise to note that this new magazine is Volume 32, No. 1. This does not mean that the Editor feels as if he had worked on thirty-two volumes instead of one. Volume 32 would be the designation of the next issue of Technical Association Papers, the time-honored name given to the volumes of transactions issued by the Association. Precedent for this was recently established by the American Institute of Chemical Engineers when it changed its publishing practice by creating a new monthly magazine—*Chemical Engineering Progress*—to succeed its annual Transactions, previously published as a quarterly.

It is felt that this designation for *Tappi* will minimize some confusion that might otherwise exist in the bibliography and magazine indexing field. In this connection it may be added that the contents of *Tappi* will be indexed in both the Engineering Index and the Industrial Arts Index which are the principal international clearing houses for technical information.

Benjamin Franklin Discusses Papermaking

If the Technical Association had existed in the Post-Revolutionary Period a speaker at one of its meetings would probably have been the great early American statesman, Benjamin Franklin. At the meeting of the American Philosophical Society held at Philadelphia on June 20, 1788, he read a paper entitled "Description of the Process to Be Observed in Making Large Sheets of Paper in the Chinese Manner, with One Smooth Surface."

It was published in the Transactions of the Society (Vol. 3, pp. 8–10) and read as follows:

"In Europe to have a large surface of paper connected together and smooth on one side, the following operations are performed:

1. A number of small sheets are to be made separately.
2. These are to be couched, one by one, between blankets.
3. When a heap is formed it must be put under a strong press to force out the water.
4. Then the blankets are to be taken away one by one and the sheets hung up to dry.
5. When dry they are to be again pressed, or if to be sized, they must be dipped into size made of warm water, in which glue and alum are dissolved.
6. They must then be pressed again to force out the superfluous size.
7. They must then be hung up a second time to dry, which if the air happens to be damp, requires some days.
8. They must be taken down, laid together, and again pressed.
9. They must be pasted together at their edges.
10. The whole must be glazed by labour, with a flint.

(continued on page 22 A)

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EDITORIAL COMMENT

(continued from page 20 A)

"In China if they would make sheets, suppose of four and a half ells long and one and a half ells wide, they have two large vats, each five ells long and two ells wide, made of brick, lined with a plaster that holds water. In these the stuff is mixed ready to work.

"Between these vats is built a kiln or stove, with two inclining sides; each side something larger than the sheet of paper; they are covered with a fine stucco that takes a polish, and are so continued as to be well heated by a small fire circulating in the walls.

"The mould is made with thin but deep sides, that it may be both light and stiff. It is suspended at each end with cords that pass over pulleys fastened to the ceiling, their ends connected with a counterpoise nearly equal the weight of the mould.

"Two men, one at each end of the mould, lifting it out of the water by the help of the counterpoise, turn it and apply it, with the stuff for the sheet, to the smooth surface of the stove, against which they press it, to force out a great part of the water through the wires. The heat of the wall soon evaporates the rest, and a boy takes off the dried sheet by rolling it up. The side next to the stove receives the even polish of the stucco, and is thereby better fitted to receive the impression of fine prints. If a degree of sizing is required, a decoction of rice is mixed with the stuff in the vat.

"Thus the great sheet is obtained, smooth and sized, and a number of the European operations saved.

"As the stove had two polished sides, and there are two vats, the same operation is at the same time performed by two other men at the other vat, and one fire serves."

The TAPPI Bulletin

The year just ended brought an end to an Association landmark—The TAPPI Bulletin. This four-page periodical served a useful purpose and its contents brought hundreds of comments and inquiries from readers. In fact, many nonmembers subscribed to it for reasons best known to themselves. It was started in 1942, following the fall meeting held in Boston, as the result of a plea presented by a member at that wartime meeting, for an Association medium that would serve to unify the technical war effort of the industry by publicizing the needs of the Armed Services with respect to paper products.

Following the War it continued as an interpreter of significant technical advances and as a sounding board or house organ to keep its readers informed concerning Association activities. It was written in popular style to interest everyone and seemed to accomplish this purpose. Sometimes its feature articles hit the jackpot and hundreds of extra copies were requested by individuals and companies.

From November, 1942, until the end of 1948 about 360,000 words were printed. Aside from the feature articles, there were a few special departments that were repeated throughout its life: Activities of the Technical Association, Paper and Packaging Specifications of the Government Agencies, New Products Clearing House, Packaging Literature Abstracts, and Miscellaneous Items. The development of packaging materials was one of the industry's greatest contributions to the war effort. Napoleon said that an army travels on its stomach. In the recent war this could not have been accomplished so successfully without good packaging materials and methods. So successful was the packaging job that when the war was over even the fleet was enclosed in capsules and stored away for future use. Let us say that the Bulletin is stowed away in WVP laminates and perhaps it may have to be restored to service from time to time to meet special needs.

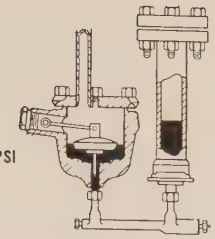
Our Advertisers and Sustaining Members

Throughout the pages of this magazine are advertisements of the companies that serve the needs of our pulp and paper mills. Most of the advertisers are also sustaining members of the Technical Association.

They advertise to sell their products. However, in soliciting these companies to purchase advertising space we quickly became cognizant of an underlying sentiment in the response. It was one of good will. An executive of one of these companies expressed it about as follows: "We understand that TAPPI is going to publish its own magazine. If so we want you to know that we are right behind you, not only with well wishes but with a contract for advertising space if you plan to make it available."

The Technical Association is proud of the companies that are associated with it as sustaining members and advertisers. The fall meetings of the Association during the past few years have been featured by organized visits by our members to their plants to see how the products used in the mills are made.

The job of selling advertising space in these current issues should have been difficult and expensive. We had no magazine to show and, in effect, called on our allied industries to have faith in the merits of this unborn publication. Over the years these companies and TAPPI have become good friends, rich in mutual respect. They know that the Association is deeply serious in its endeavors. They know that the Association is a hard taskmaster in its demands for quality and good workmanship. They know that the Association is organized for the search and dissemination of knowledge about everything that will improve the paper and pulpmaking processes, raise quality, and lower costs. Their aim is to assist in this objective. Their advertisements reflect this attitude. Their advertisements are part of the technical literature and will help the readers of *Tappi* to keep up to date with the technical progress, quite as much as the more detailed technical reports that constitute the great service of this magazine to the industry.



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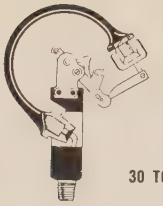

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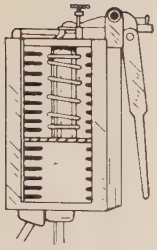

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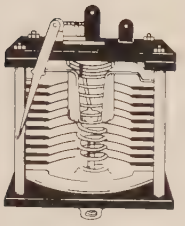

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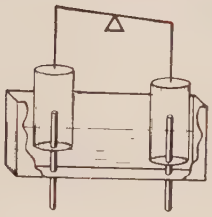

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TAPPI Annual Meeting Papers

The following papers and reports are tentatively scheduled for presentation at the annual meeting of the Technical Association of the Pulp and Paper Inindustry to be held at the Commodore Hotel, New York City, on February 21–24, 1949.

Opening Session

1. Secretary's Report, by R. G. Macdonald
2. President's Address, by W. F. Gillespie
3. TAPPI Medal Award to Hardy S. Ferguson
4. "Our Growing Water Problem," by Edward N. Munns, Chief, Division of Forest Influences, U. S. Dept. of Agriculture, Washington, D. C.

Committee Meetings

Monday afternoon, February 21st, will be reserved principally for meetings of all the Association's committees to discuss current projects and plan future work.

Structural Fibrous Materials

1. "An Engineering Approach to the Mechanical Testing of Fiber Boards," by Wayne C. Lewis, Forest Products Laboratory, Madison, Wis.
2. "Evaluation of Fibrous Agricultural Residues for Structural Building Board Products. Part 3. Additional Studies of Wheat Straw Fiber," by E. C. Lathrop and T. R. Naffziger, Northern Regional Research Laboratory, Peoria, Ill.
3. "A Quality Control Method for Insulating Board Pulp," by Henry Mohrer, C. S. Conover, and O. W. Frost, U. S. Gypsum Company, Chicago, Ill.
4. "Sizing of Insulating Board," by Hercules Powder Company, Wilmington, Del.
5. Panel Discussion on Coatings for Insulating Board, led by J. A. Killinger, Penick & Ford Ltd., Cedar Rapids, Iowa, and F. W. Egan, Bound Brook, N. J.
6. "Williams Freeness Test Studies on Insulating Board Stock," by C. E. Hrubesky, Forest Products Laboratory

Statistics

1. "Testing and the Statistician," by J. B. Catlin, Kimberly-Clark Corporation, Neenah, Wis.
2. "Statistical Control of Paper Quality—Basis Weight and Moisture Content," by Charles M. Koon, Munising Paper Company, Munising, Mich.
3. "Treatment and Mistreatment of Experimental Data," by T. K. Sherwood and H. S. Mickley, Mass. Inst. of Technology, Cambridge, Mass.
4. "The Detection and Control of Tester Error," by J. H. Strieby, Kimberly-Clark Corporation, Neenah, Wis.

Pulping and Related Processes

1. "Lime-Sludge Recovery in Sulphate Mills," by W. H. Tock, Engineer, Pyro-Processing Section, Allis-Chalmers Mfg. Company, Milwaukee, Wis.
2. "Research Laboratory Facilities for Pulping Studies," by William J. Nolan, Engineering and Industrial Experiment Station, University of Florida, Gainesville, Fla.
3. "Effect of Buffering Agents in Sodium Sulphite Semichemical Pulping," by J. N. McGovern and E. L. Kelly, Forest Products Laboratory
4. "Steam and Water Cooking of Aspen Chips," by J. N. McGovern and K. J. Brown, Forest Products Laboratory
5. "Pulping of Redwood," by Harry F. Lewis, and L. V. Forman, Inst. of Paper Chemistry, Appleton, Wis.
6. "Spray Drying Coefficients of Sulphite Waste Liquor," by L. C. Jenness, University of Maine, Orono, Me.
7. "Commercial Lignins," by Arthur Pollak, New York, N. Y., and Robert S. Aries, Brooklyn Polytechnic Inst., Brooklyn, N. Y.
8. "A New Mechano-Chemical Process for Pulping Agricultural Residues," by S. I. Aronovsky, Northern Regional Research Laboratory, Peoria, Ill.
9. "The Solubility of Sulphur Dioxide in Magnesium Bisulphite Solutions," by F. H. Conrad, Missouri School of Mines, Rolla, Mo.
10. "The Effect of Sodium Peroxide Bleaching on the Components of Spruce Groundwood," by Gary W. Jones, Consolidated Water Power & Paper Company, Stevens Point, Wis.

Water Technology

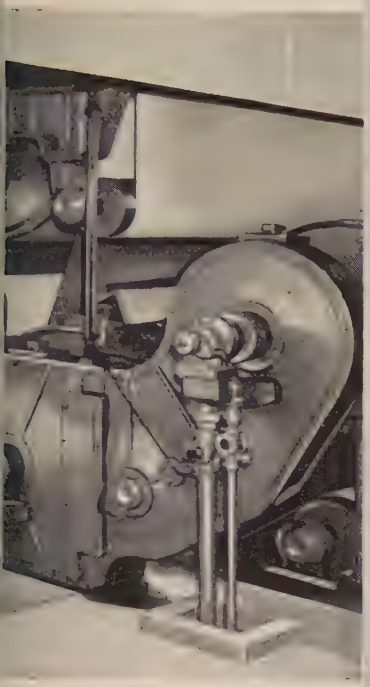
Biochemical Oxygen Demand Session

1. Paper, by Harry S. Gehm, National Council for Stream Improvement, New York, N. Y.
2. "Stream Pollution from Virginia Pulp Mills," by A. H. Paessler, Virginia State Water Control Board and L. L. Hedgepeth, Calco Div., American Cyanamid Company, Bound Brook, N. J.
3. Paper, by D. Paul Rogers, Pennsylvania Department of Health, Harrisburg, Pa.
4. Paper, by F. W. Kittrell, Tennessee Valley Authority, Knoxville, Tenn.

(continued on page 26 A)

PAPER · · · America's 6th Industry

Cutaway view of Puseyjones Improved Steam Joint



eyjones Improved Steam Joint in-
ed on Dry Part having enclosed
e gearings. Can also be used on
Part with open type gearing by
ching bracket to special outside
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porting bracket for Puseyjones Im-
ved Steam Joint with vertical steam
water piping attached. See water
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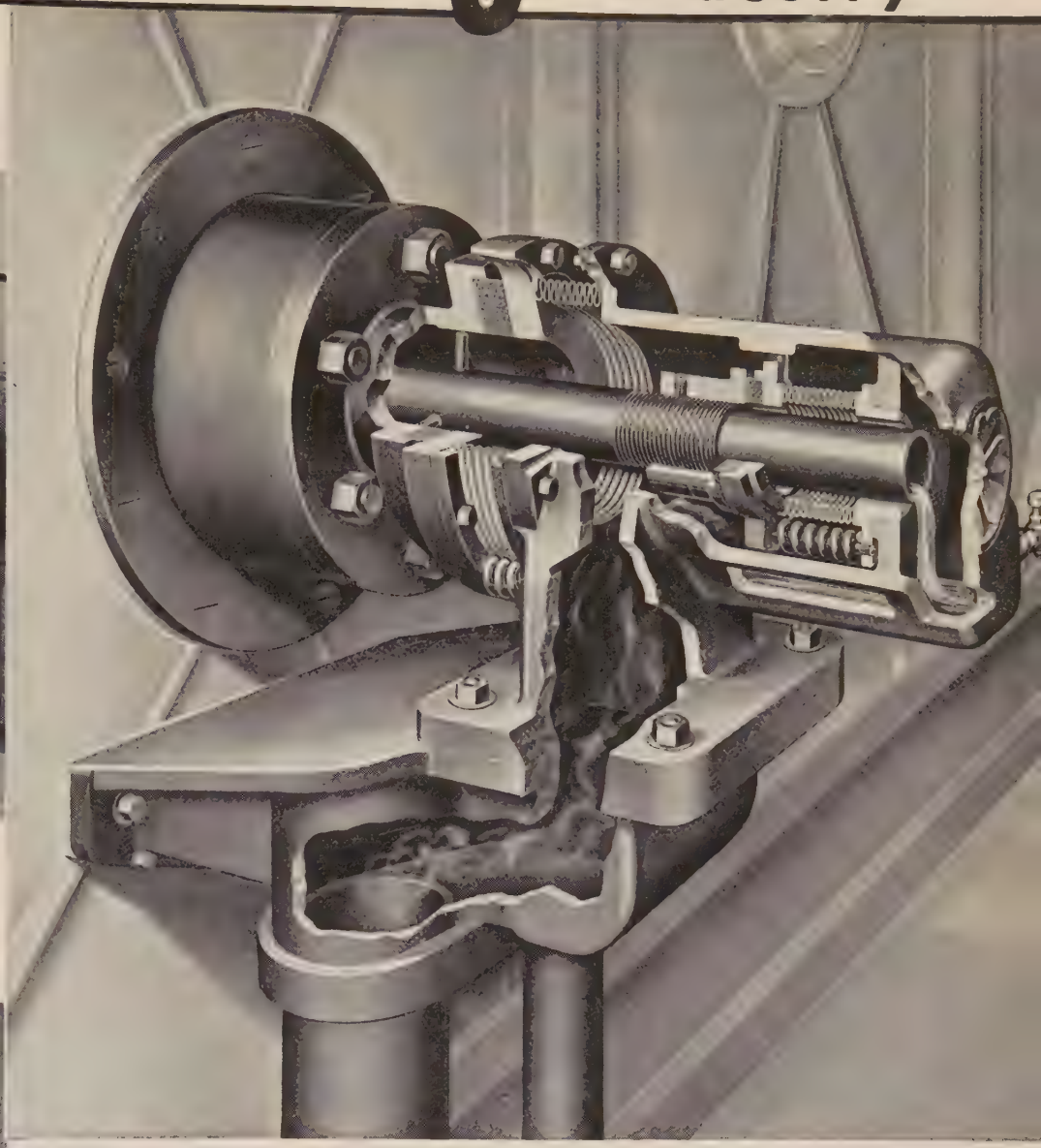

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In the "Steam Joint Bulletin," we give full details on this remarkable new development, describing its application in connection with modern siphon type evacuators. Write for your copy today.

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Wilmington 99, Delaware, U. S. A.

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Annual Meeting Papers

(continued from page 24 A)

5. "Aeration of Rivers," by L. Warrick, State Sanitary Engineering, Madison, Wis.
6. Paper, by George Borden, Riegel Paper Corporation, Milford, N. J.

Water Coagulation Session

1. "Cooling Water," by V. J. Calise, Liquid Conditioning Corporation, Linden, N. J.
2. "The Savalla Saveall," by B. Nyberger, Castle & Overton Company, New York, N. Y.
3. Paper, by Paul Easton, Bulkley, Dunton Company, New York, N. Y.
4. Paper, by A. C. Brumley, Alhydro, Inc., Baltimore, Md.
5. Paper, by R. F. Clemons, The Dorr Company, New York, N. Y.
6. Paper, by Ranney Water Collector Corporation, New York, N. Y.
7. "Settling Waste Materials from Pulp and Paper Mill Waste Waters and Handling Bulk Solids Over Experimental Vacuum Filters of the Komline and Dorr Types," by A. S. Erspamer, P. H. Glatfelter Company, Spring Grove, Pa.

Plastics

1. "New Type Phenolic Resins for Paper-Base Laminates," by M. P. Seidel, Westinghouse Research Laboratories, Pittsburgh, Pa.
2. Other papers to be announced

Graphic Arts

1. "Paper," by E. F. Carman, Montclair, N. J.
2. "Measuring Ink Coverage for Four-Color Webb Printing," by Edward R. Duffie, Meredith Printing Company, Philadelphia, Pa.
3. "Four-Color Webb Offset Printing," by Milton Zucker, Interchemical Corporation, New York, N. Y.

Wet-Strength

1. "A Review of Wet Strength Paper," by Borje Steenberg, Swedish Forest Products Laboratory, Stockholm, Sweden.
2. "Bonding Materials to Cellulose," by Herman Mark, Polytechnic Institute of Brooklyn
3. "Review of Concepts of Bonding of Fibers and Additives," by Wilfred Gallay, E. B. Eddy Company, Hull, P. Q.

Microbiological Control Methods

1. "Equipment for Feeding Slime Control Toxicants Into Paper and Pulp Mill Systems," by Charles W. Dean, Buckman Laboratories, Memphis, Tenn.
2. "A Resistant Species of Penicillium from Groundwood Pulp," by J. W. Appling, Buckman Laboratories
3. "Establishing a Nontoxic Germicide," by C. H. Rogers, R. T. Vanderbilt Company, East Norwalk, Conn.
4. "Bioassay of Slime Control Agents," by B. F. Shema, Inst. Paper Chemistry
5. "Lethal Effect of Drier Rolls on Bacteria," by B. F. Shema

Containers

Symposium on Adhesives

1. "Studies in Water Resistant Pastes," by Edward H. Hill, Corn Products Refining Company, New York, N. Y.
2. Other papers to be announced

Paper Making and Stuff Preparation

1. "Engine Sizing as a Substitute for Beating," by W. S. Wilson, Monsanto Chemical Company, Everett, Mass.
2. "Curlated Pulp—A New Approach to Pulp Processing," by H. S. Hill, J. Edwards, and L. R. Beath, Price Brothers & Company, Ltd., Quebec, P. Q.
3. "The Curlator—Its Application to High Yield Newsprint Sulphite—Preliminary Report by Frank P. Silver," Price Brothers & Company, Ltd., Riverbend, P. Q.
4. "The Two-Sidedness of Colored Paper," by H. A. Lips, Dyestuff Div., E. I. du Pont de Nemours, Wilmington, Del.
5. "The Kenwood Wheel as an Operating Tool," by Irving H. Peters, F. C. Huyck & Sons, Albany, N. Y.
6. "The Mechanism of Softening Paper by Glycerine," by Wm. McPherson, Jr. International Paper Company, Glens Falls, N. Y.
7. "The Alkaline Hypochlorite Oxidation of Guar Mannogalactan," by Arthur J. Haug, Scott Paper Company, Chester, Pa.
8. "The Correlation Between Hemicelluloses and the Physical Properties of Bleached Kraft Pulps," by Francis T. Ratliffe, Johns-Manville, Inc., Manville, N. J.
9. "Increasing the Use of Deciduous Wood Fibers in Offset Papers by Resin Bonding," by C. G. Weber, National Bureau of Standards, Washington, D. C.

Mill Instrument Control

1. "Principles Governing the Choice Between Electric and Nonelectric Instruments," by David H. Fuller, The Foxboro Company, Foxboro, Mass.

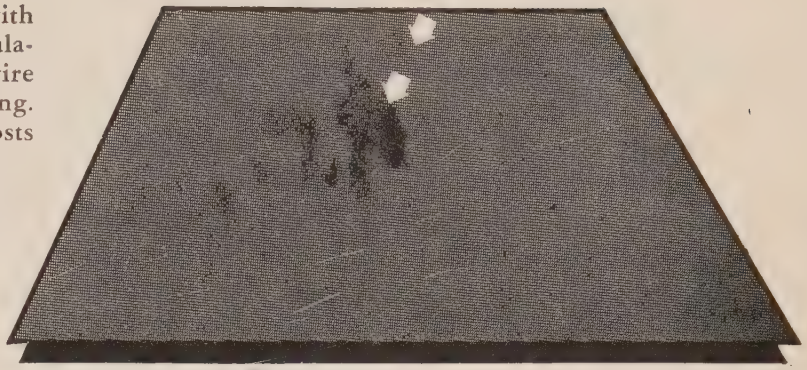
Annual Luncheon

Address by D. Clark Everest, President, Marathon Corporation, Rothschild, Wis.

Here's the Pitch

—that cuts profits

Many paper makers are plagued with pitch trouble. Even a small accumulation of pitch on the Fourdrinier wire may force a shutdown for cleaning. Valuable time is lost. Maintenance costs go up. Profit goes down.



Here's the Cure

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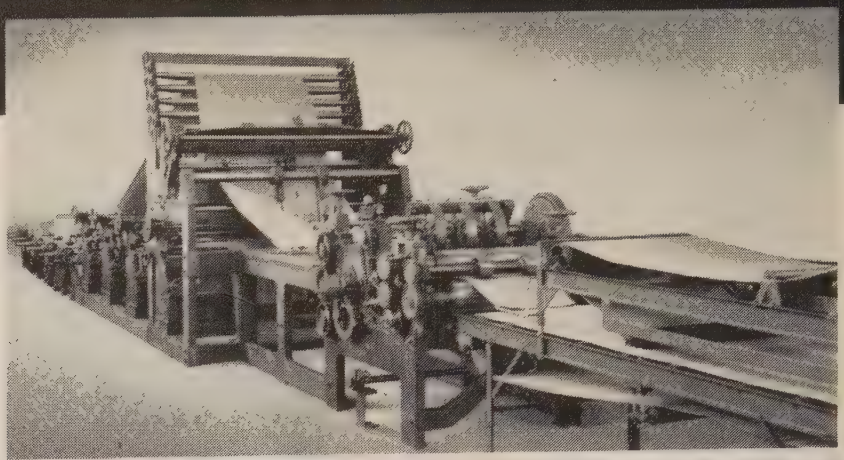

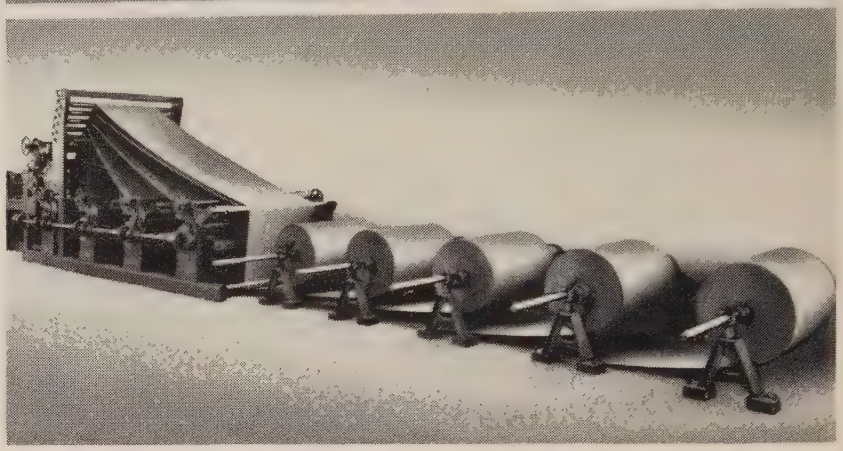

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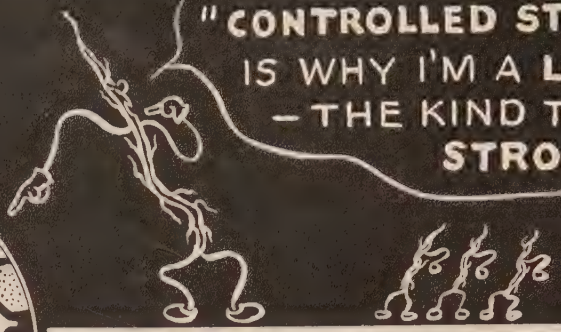
Diagrammatic sketch of Norton Pulpstone showing the uniform, controlled grain spacing that produces long, uniform fibers.



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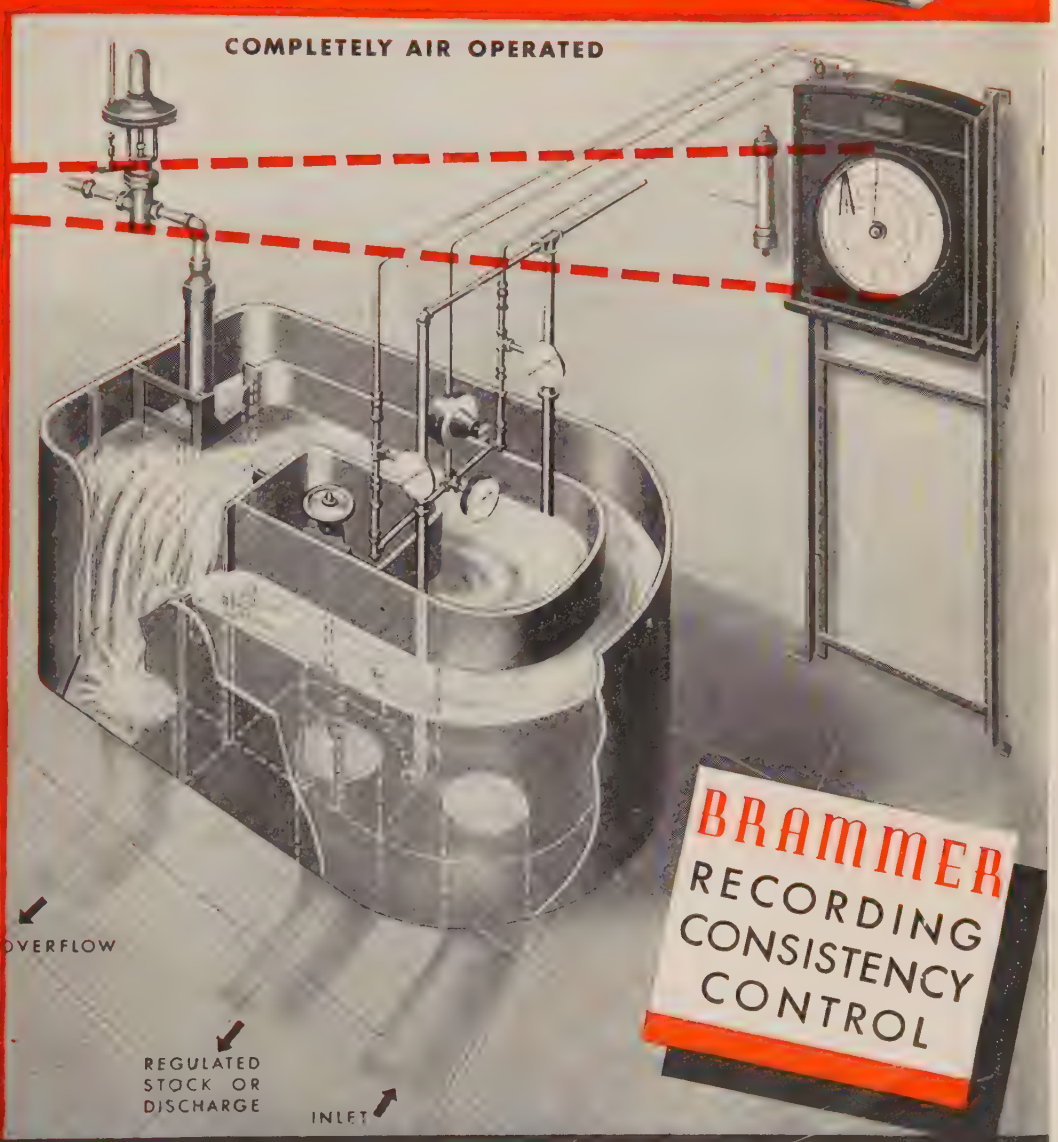

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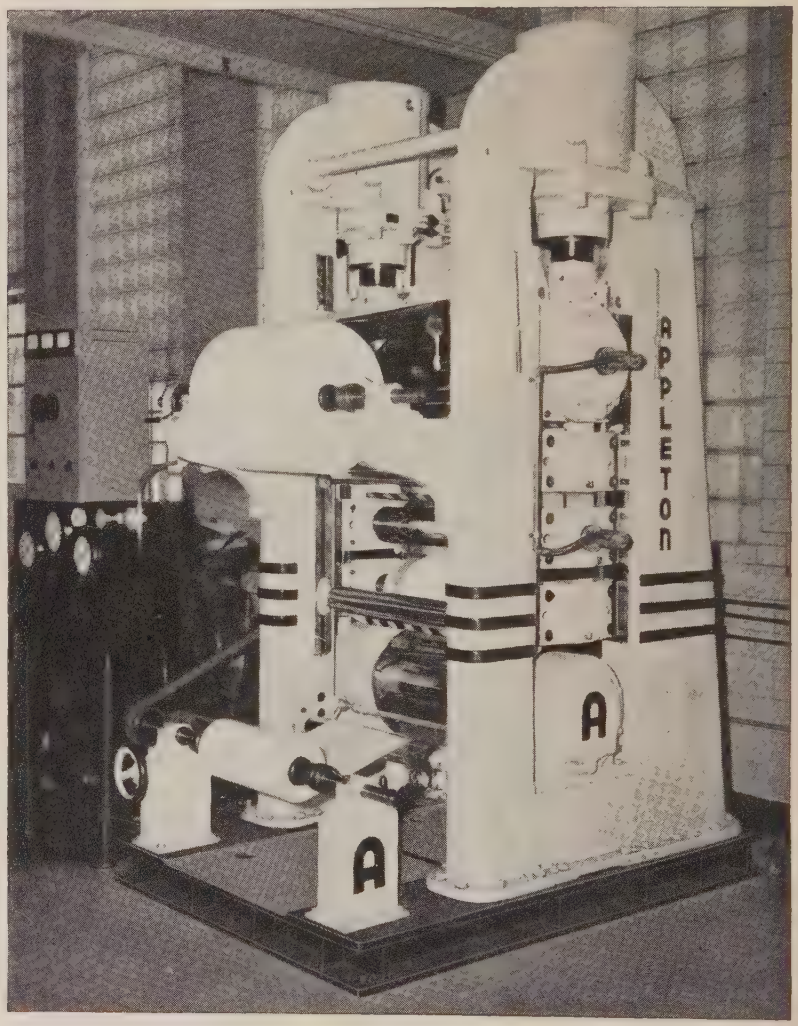

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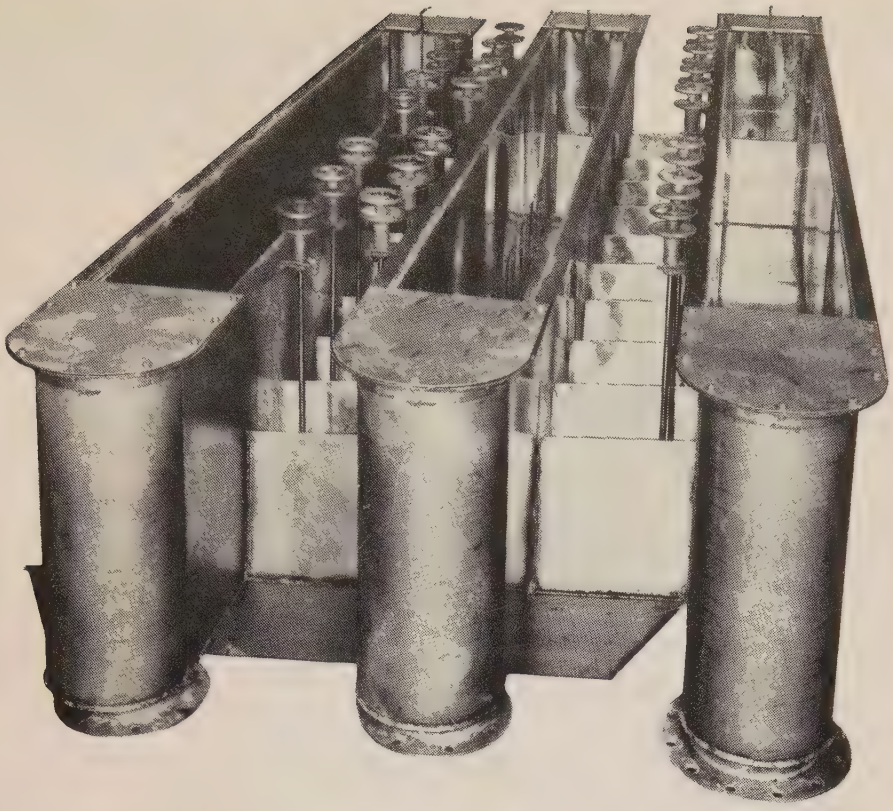

Board machine headbox made of ⅛" sheet Monel. Interior surfaces are polished "35" Monel to prevent fiber accumulation. Fabricated by Brown-Hutchinson Iron Works, Detroit, Michigan, for the River Raisin Paper Co. of Monroe, Mich.

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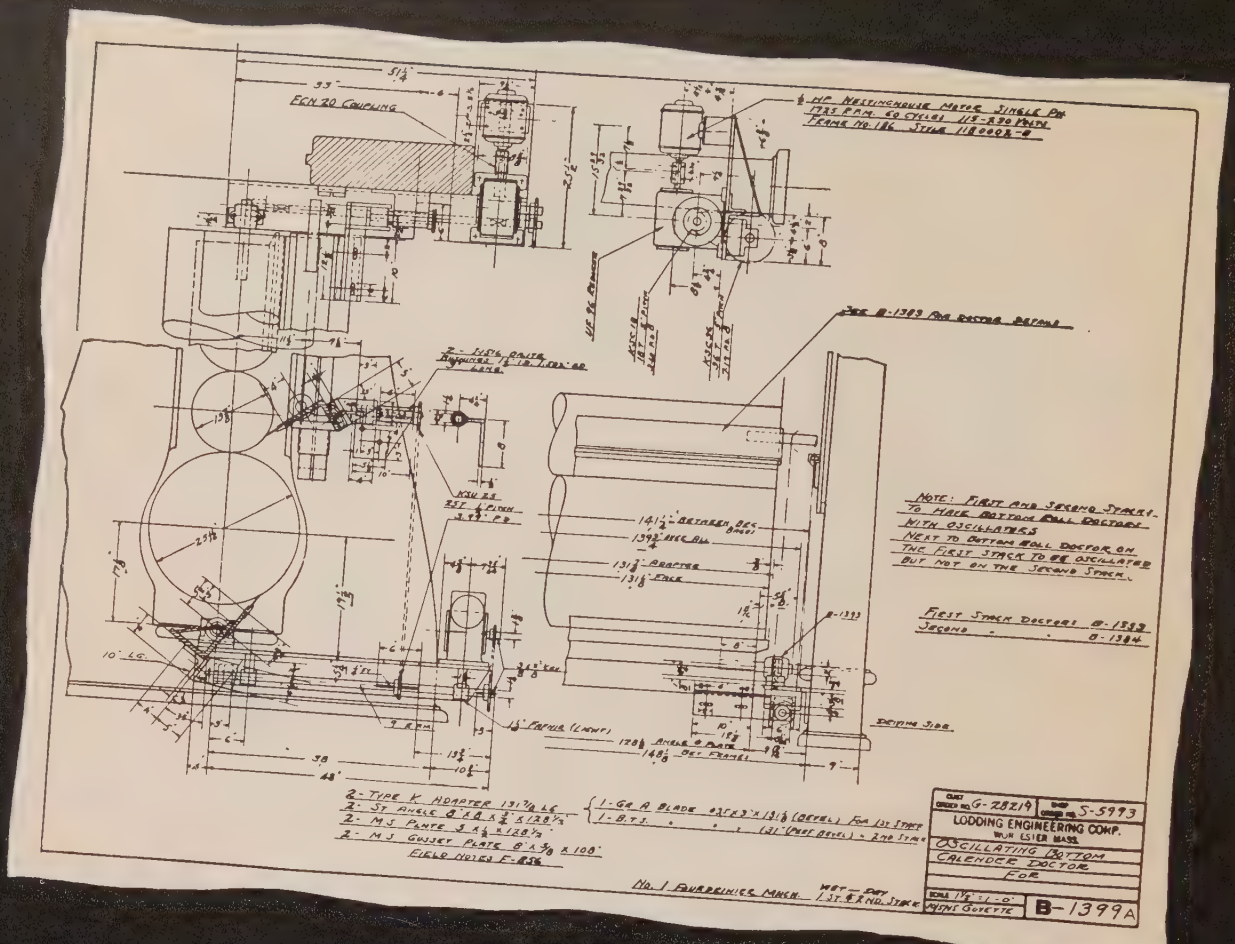

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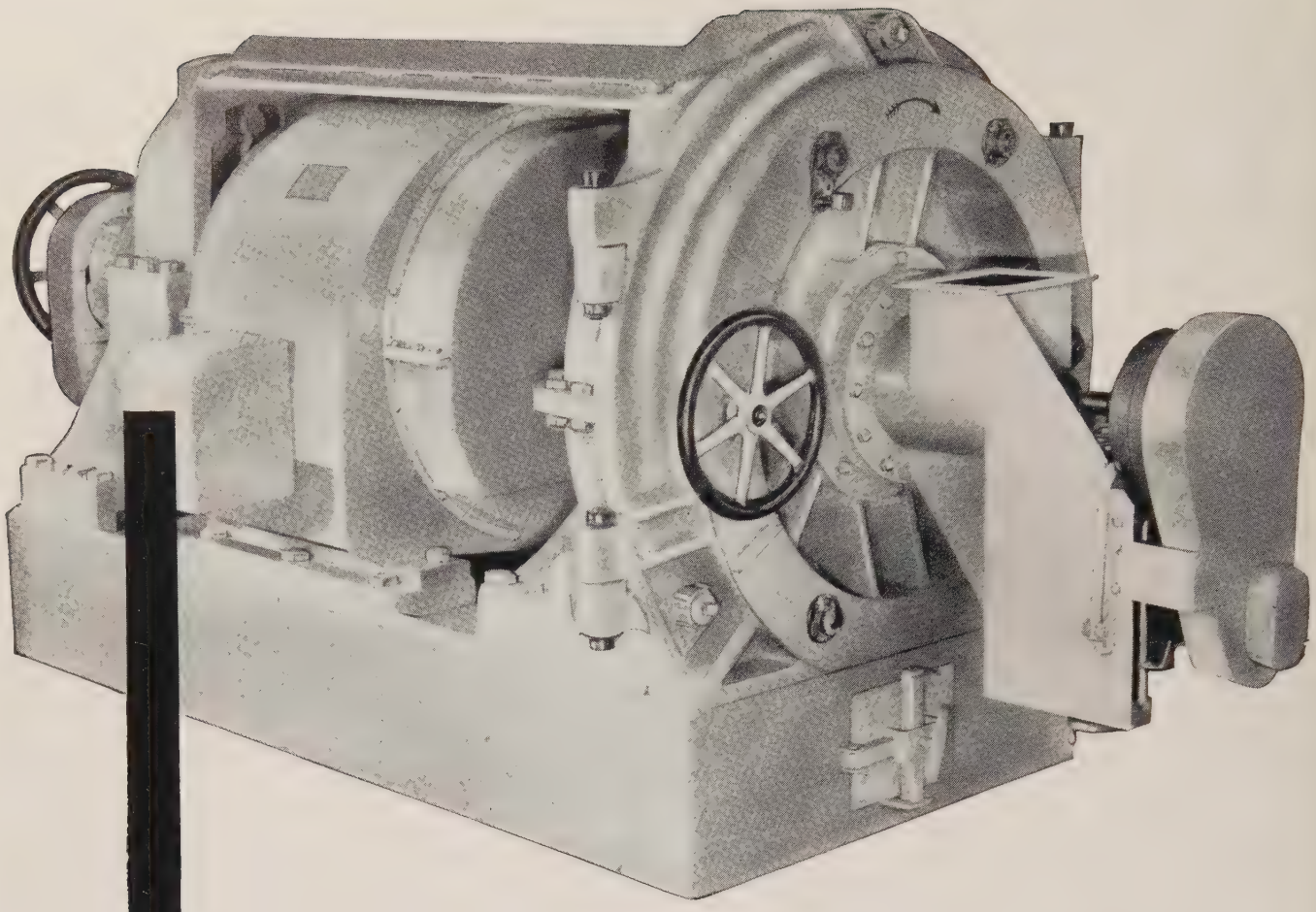

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64

Southern Pulpwood in Perpetuity?

VERTRIES YOUNG

The problem of an adequate pulpwood supply is common to every pulp manufacturer. An indication of the problems and opportunities existing in the South are presented together with suggestions for the development of an adequate forestry program.

In 1947 the Technical Association of the Pulp and Paper Industry published its Monograph No. 4 "Pulpwood Stands, Procurement, and Utilization," a very complete and interesting series of studies on the stands, procurement, and utilization of pulpwood in the entire United States. In the face of such monumental work it is difficult to set down any new thought on the pulpwood supply problem of even a limited region, in this case the South. This article, therefore, will of necessity draw heavily on the material contained in that monograph, but will endeavor to set forth from the mill operator's viewpoint certain procedures that will have to be followed by wood-using industries if the South is to be assured of a perpetual supply of forest products in the face of the gradually increasing demand.

Every mill executive is concerned with the probable adequacy of his future pulpwood supply. Whether his mill is an old one or a new one it represents in terms of cost replacement or cost of construction a far greater investment than a mill of the same size built 10 years ago. If it runs out of wood it cannot be moved; if it is short of a full supply of wood, continuing fixed charges will make partial operation well-nigh impossible in a competitive market. The protection of that investment is, therefore, a major responsibility of the mill executive and of the other officers and directors of the company as well.

Fee ownership of timber lands properly stocked and managed is, on the surface, the surest guarantee of a permanent wood supply. Mr. Cruikshank in his article in the TAPPI Monograph, "Southern Forests as a Source of Pulpwood," advocated a program of forest land acquisition, but at the same time pointed out the dangers inherent in complete self-sufficiency. Too great concentrations of timber ownership in limited localities make a mill vulnerable to weather conditions, sufficiency of local woods labor, and tie-ups in transportation facilities.

While most mills were built with some back-log of forest lands in fee ownership, there are probably few, if any, that own enough lands to be self-sufficient even after those lands have been brought into full production. If a mill is not already self-sufficient the cost of acquiring enough timber lands at present is well-nigh out of the question. In addition to the heavy investment required there is the further consideration of the annual carrying charges, principally for taxes and fire protection which in bad times may constitute a heavy burden. Finally, there is the question of whether, over an extended period, it is cheaper to own and grow timber than to buy it on the market.

Each mill must determine for itself what seems an adequate fee ownership of forest lands taking into consideration its cash resources for an investment of this type, the nature and extent of forest ownerships in its tributary territory, the competition for pulpwood and other forest products, and the total forest resources of that territory. It must also forecast its future pulpwood requirements and determine with more than rule-of-thumb accuracy the future potential growth on its lands. The latter evaluation alone, if projected over a 15- or 20-year period, will disclose the need for the best type of forest management to develop the full capacity of its lands. The importance of this can not be overstressed as these lands are already incurring taxes, and in most cases are protected against fire, all at considerable expense to the pulp mill.

After the foregoing study is completed (and it will not be done in the course of a day) there still remains the question of how far to go in additional land acquisition. *The purpose of this article is to attempt to point out that of equal importance with land aquisition is an active program in conjunction with other mills and wood-using industries to aid in perpetuating the timber resources of its tributary territory. This program cannot succeed unless it has the continuous and active support and attention of top management.*

WOOD PRODUCTION

A look at the statistics disclosed for the South as a whole by the United States Forest Service's 1945 "Reappraisal of Forest Resources," will serve to bring out the problems and opportunities peculiar to that region. Four basic facts stand out very clearly:

1. Commercial forest lands in the 12 Southern States comprising Region 8 of the Forest Service (North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, East Texas, Oklahoma, Arkansas, Tennessee, and Virginia) total 183,266,000 acres and represent 56% of the total land area of the region. A total of 122,060,000 acres of this commercial forest land in 1945 was in 1,649,456 small ownerships of 5000 acres or less. The average of such ownerships was approximately 75 acres. For the region as a whole there appears to be little likelihood that large ownerships will ever control the bulk of the region's timber production providing the small ownership can be kept in *active* and *sustained* production.

In 1947, pulp mill ownerships were estimated at 6,000,000 acres, against an annual consumption at that time of about 8,000,000 cords of wood. While these lands are probably better stocked and certainly better managed than the average forest lands of the South, the annual growth of pine at the present time

VERTRIES YOUNG, Executive Vice-President, Gaylord Container Corp., Bogalusa, La.

Fig. 1. Vertical aerial photograph showing residual trees in 26-year-old loblolly pine plantation burned in 1938. Fire path light area from upper left to lower right of 40-acre block

would probably not average more than 0.6 cord per acre on the 6,000,000 acres or roughly 3,600,000 cords a year, or 45% of requirements. Much of this wood is being allowed to grow, i.e., to increase the growing stock and, ultimately, the rate of growth per acre. In the course of time the 6,000,000 acres should be able to grow 75% of the 1947 wood consumption.

2. For the region as a whole, despite heavy cutting, the Forest Service estimates that growth of trees of all species 5 inches in diameter and up from 1935 through 1944, was only 0.8 of 1% less than the drain from all causes. In the year 1944 growth was 4.3% less than drain. These figures appear encouraging until further broken down, and it then develops: (a) that the volume of saw timber (of all species) declined 9.6% in the 10-year period, and 22.6% in 1944; and (b) that pine is showing the greatest decrease in total volume, while hardwoods, particularly in small diameter trees, are on the increase. In 1944 according to figures cited by James W. Cruikshank the volume of pine decreased by 2,600,000 cords or 3%, while hardwoods increased by 1,800,000 cords of 1.5%.

These figures on the decline of pine growing stock percentagewise do not look too serious but occurring at a time when additional pulp mills are coming into production, they may pose a very real problem in sections where the drain is particularly heavy. An increase in the pine growing stock in East Texas is not of great benefit to a mill in Georgia or North Carolina.

The figures showing the increase in the hardwoods are serious indeed. In 1944 the volume of hardwoods of saw timber size declined 2,243,000 board feet or roughly 4,500,000 cords, but total volume of hardwoods 5 inches and up increased 1,800,000 cords! There is ample visual evidence that the upsurge is occurring on lands formerly occupied by pine. It is becoming increasingly recognized that this constitutes one of the South's most serious forestry problems.

3. Pulpwood consumption still constitutes a relatively small percentage of the total drain on the South's forests. In 1944, it accounted for only about 8,000,000 cords or 10% of the total commercial drain of 82,400,000 cords. Fire and disease, in addition to the total commercial drain, accounted for 12,900,000 cords. But once again, figures must be broken down further to disclose the significant facts. Pulpwood accounted for 17% of the commercial drain on pine, and only 2% of the commercial drain on hardwoods. Lumber accounted for 55% of the drain on pine and 46% on hardwoods; fuel wood, 18% on pine and 24% on hardwoods. In the face of the upsurge of hardwood, it is evident that one of the primary problems is to find increased uses for this material in pulp and papermaking.

4. The South is still far below its potential capacity as a timber growing region. Again citing figures by Mr. Cruikshank, of the 183,266,000 acres of commercial forest land, 32.6 million acres are bare or have less than 40% stocking. Of 128,000,000 acres classed as saw timber or pole lands, only 25% are well stocked; 75% are understocked. It is Mr. Cruikshank's opinion that with good fire protection, planting where needed, and good forest management in general use, the pine growth in the South could actually be *doubled*. Asked if he might be quoted as the authority for this opinion, his rejoiner was, "Yes, but some may think the estimate overly conservative!"

What does it mean? The growth of pine in the South in 1944 was estimated at 50,300,000 cords. Let us admit the impossibility of ever attaining perfection in the items mentioned above particularly since we have to meet the country's heavy demands for forest products as we go along. If 50% of this goal could be reached we could add 25,000,000 cords a year to our annual pine growth; 20% attainment would add 10,000,000 cords a year which is probably in excess of the total 1948 consumption of all pulpwood in the entire South.

Fig. 2

FORESTRY PROGRAM

As a nation we are prone too often to think of ourselves as reaching the point of action only when driven thereto by extremity. There is no doubt that widespread fires and destructive cutting creating the justifiable fear of an early end to the timber resources of certain states, have been powerful stimulants to action in setting up statewide "Keep Green" movements and other efforts at forest perpetuation. Industry, if it has the acumen and farsightedness with which it likes to credit itself, does not need to wait for disaster to overtake it before taking action. The lumber industry and the pulp mills have both the opportunity and the obligation, as the principal forest products users, to take the initiative in doing their part to make some substantial portion of this possible gain a reality. A measurable success in this effort will greatly strengthen their position as responsible and valuable units in the economic life of the South and add material insurance to the permanence of their operations in so far as raw materials are concerned. Such a program merits the active and continuing attention of top management in every unit in both industrial groups.

What avenues of attack are open? The lines have been well laid down, many times and in many places, but let us review them briefly.

Avenue 1.—Fire Protection: This has received increasing attention, year by year, and in many states the results are already apparent. It is amazing how seedlings will spring up, in areas protected from fire, even where there is little if any source of seed in sight. Pine seeds are frequently carried by the wind from $^1/_4$ to $^1/_2$ mile. Most of the 32.6 million acres of denuded and understocked lands are in that condition solely because repeated grass fires have killed all seedlings year after year. Active support of state forestry organizations, insistence on good fire protection, and continuing programs of education on the evils of wood fires are all tried and proved means of accomplishing results. In this connection, there is still a widespread but mistaken belief that woods fires do little damage to standing timber after it reaches a few feet in height. The damage is not confined to small trees.

Fig. 3. Gaylord Container Corporation fire prevention poster emphasizing local employment

Fig. 4. Natural reproduction from slash pine seed trees

Figure 1 is an aerial view of a 40-acre portion of a plantation just north of Bogalusa, La. The trees were planted about 1924 and in 1938 or 1939 a hot fire burned through the entire forty. The trees in the diagonal space in the center were killed outright. The trees on the fringe were not killed, and to all outward appearances they seem normal, if their age and history are not known. Figure 2, however, is a cross section of one of those trees, cut in November, 1947. The reduction of growth rate, indicated by the narrow annual rings beginning 8 or 9 years ago, is all too apparent.

Avenue 2.—Utilization of Hardwoods: While woods fires have been Public Enemy No. 1 to the South's second-growth forests, there is a strong possibility that the hardwood invasion may take rank not far below, as Public Enemy No. 2. This is all the more so because in certain sections of the South, thinning or stand-improvement cuts of pine have seemingly had the effect of opening up the timber enough to permit shade-tolerant hardwoods to take over the openings to the exclusion of pine seedlings. A subsequent cut of pine leaves the land in full possession of the hardwoods. In many sections of the South, presently useless hardwoods already occupy much valuable space in pine stands. One beneficial effect of the heavy wartime demand for timber has been the opportunity which it afforded to cut vast quantities of low grade hardwoods for which there had been almost no prewar demand. At least the larger hardwoods were removed, and many culls and "wolf trees" were cut into ties, but at the same time heavy pine cuts occurred. The removal of the larger low grade hardwoods was a gain, but in many cases it simply meant more room for more small hardwoods. The problem seems to be to find a use for greater quantities of hardwoods of pulping size, or on forest sites that are primarily dedicated to pine, find a means for destroying the hardwoods. In bottom lands and typically hardwood areas, or where good specimens of a valuable species are found in pine stands, let them grow for their intrinsic value.

The problem of finding a pulping use in quantity for hardwoods poses a challenge to the best technical brains. Small quantities are now used by most mills mixed with pine. Several mills use gums in making corrugating material. One mill uses oak for this

Fig. 5. Company woods road through 24-year-old slash pine plantations

purpose. Dissolving pulps offer a third outlet, but the total annual use is still relatively insignificant.

Destruction of unwanted hardwoods has been accomplished by girdling and poisoning, and by the judicious use of fire in stands where the pine is large enough to be beyond danger of serious damage by a "slow" fire still capable of killing young hardwoods. This raises in many minds the question of how to be sure of getting a "slow" forest fire, and how to keep it slow, once it gets a good start. There is the further danger of undoing the good already accomplished in stamping out the practice of woods burning. Yet the practice of controlled burning has strong advocates.

Avenue No. 3.—Improvement of Cutting Practices: Years ago even before the advent of the pulp mills, saw mills sought chiefly the larger and better quality trees leaving behind the younger and poorer trees. Later, particularly in the even-age long leaf stands, clear-cutting was widely practiced, and logging with skidders caused great damage to the few small or ill-formed trees that remained. Selective cutting as originally practiced had largely given way to clear cutting. Yet in spite of this, due to seed already on the ground, or further reseeding by trees left untouched a large second-growth forest appeared on much of the cut-over lands in the South. The early pulp mills found their raw material among the smaller trees in this forest which were then unattractive to the existing saw mills. However, some clear cutting was practiced on these young stands, and it is not surprising that saw mills and the public in general came to regard the pulp mills as the destroyers of the South's future forests. A number of the early pulp mill operators recognized the evil in this situation and to correct it, pooled their then slender resources to unite through the medium of the Southern Pulpwood Conservation Association to bring about an improvement in the cutting of pulpwood. This represented the first organized effort in the United States to do something constructive on an industry-wide basis to perpetuate the forest resources of a region.

Meanwhile the depletion of the original pine forest and the high prices and unprecedented demand for lumber occasioned by the War combined to tempt the saw mills, particularly the small portable mills, to cut the smaller trees heretofore cut mainly for pulpwood. For a time almost any tree that would make a 2×4 was fair prey for a "peckerwood" as the small mills were called. About the only difference discernible between a bad pulpwood cut and a bad "peckerwood" cut was the diameters of the tops left in the woods. The pulp mills did do a generally better job of cleaning up. As a matter of fact, from the standpoint of tree utilization, the pulp mills still lead the field cutting low stumps and leaving behind little but the branches.

As matters now stand, both the pulp mills and the saw mills still have plenty of room left for improvement. Fortunately, timber is not an irreplaceable natural resource, like oil or gas, and does not need to be "conserved" in the sense that once gone it is beyond replacement. A better term than "conservation" might be "use with provision for continuous replenishment." For a specific piece of land, this would mean in its best interpretation the harvesting of mature trees and thinning smaller ones for stand improvement and removing the overcrowded and less desirable pines for pulpwood to permit more rapid growth of the better trees that remained. In this way a second and third cut could be made at perhaps 5- to 10-year intervals, and when the final harvesting cut is made,

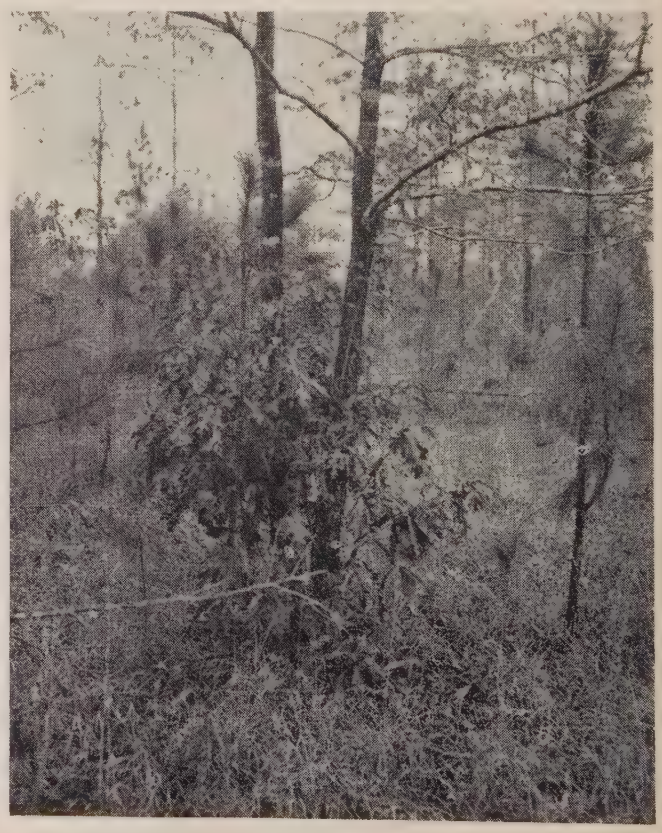

Fig. 6. Loblolly reproduction released by axe girdling of blackjack oak. Oak sprouts are 1 year old

young pines should be on the ground ready in a few years to yield a cut of pulpwood.

In a perhaps less desirable interpretation, "use with provision for continuous replenishment" might mean cutting to leave seed trees, or strip-cutting with seed trees left along the fringes, if that proves to be the best way of defeating the hardwood invasion. Such cutting still provides for replenishment although it is intermittent rather than continuous as a much longer time must elapse before another commercial cut can be made.

Pulp mill lands and many lumber company lands are cut with provision for continuous replenishment or "sustained yield" as it is generally termed. The problem before the wood-using industries is to encourage such cutting practices on private lands. Its solution involves selling the land owner on the idea, as well as the logger and the pulpwood producer. Most pulp mills, and saw mills in increasing numbers, now maintain foresters or trained woodsmen to mark a landowner's trees before cutting, designating the larger and better quality trees for piling and saw logs and the less desirable trees for pulpwood *but leaving an adequate growing stock on the land,* to provide for continuous replenishment.

While much progress has been made in this direction it is still a fact that many if not most small private holdings are still improperly cut. If the logger and pulpwood producer urge a partial cut the owner's indifference or need for ready cash may cause him to insist on clear cutting. A ready-made solution to such a problem, frequently offered, is to pass a state or federal law requiring that cutting on all lands be done with provision for replenishment. Such laws may ultimately be enacted if the industries and other agencies concerned do not succeed in educating the small landowner on the benefits of partial cutting and educating their own suppliers to cut in conformity with good forestry practices. The pulp mills cannot accomplish this singlehanded. In conjunction with the saw mills and other wood-using industries, much could be accomplished, and efforts are now underway to try out such a joint educational program in the field. The effort is deserving of full support.

Avenue No. 4—Multiple Use of Forests: Here again is a field for active collaboration between the lumber and pulp industries. It is practically impossible to grow pulpwood without growing some saw timber, and while most pulp mills are equipped to chip large diameter bolts, why cut up a 20-inch tree into pulpwood when its value as a sawlog is so much greater? Likewise saw mills leave usable tops in the woods which, at a price that allows for the extra labor required for lopping off limbs, can be converted into pulpwood. Stands of timber ultimately destined for the saw mills also require thinning for best growth, and the pulp mills afford a ready market for the less desirable trees so removed. This collaboration is constantly going on between individual pulp mills and saw mills. Its further extension will benefit both groups, effect the best utilization of forest products, and help to increase the total growth on the lands of the South.

Avenue No. 5.—Utilization of Saw Mill Refuse: It is difficult to estimate the total loss now occurring through nonutilization of saw mill refuse or how much might be saved through pulping or other types of defibering. Removal of bark is one of the problems, but handling and transportation costs may be such as to make practical large-scale use very difficult.

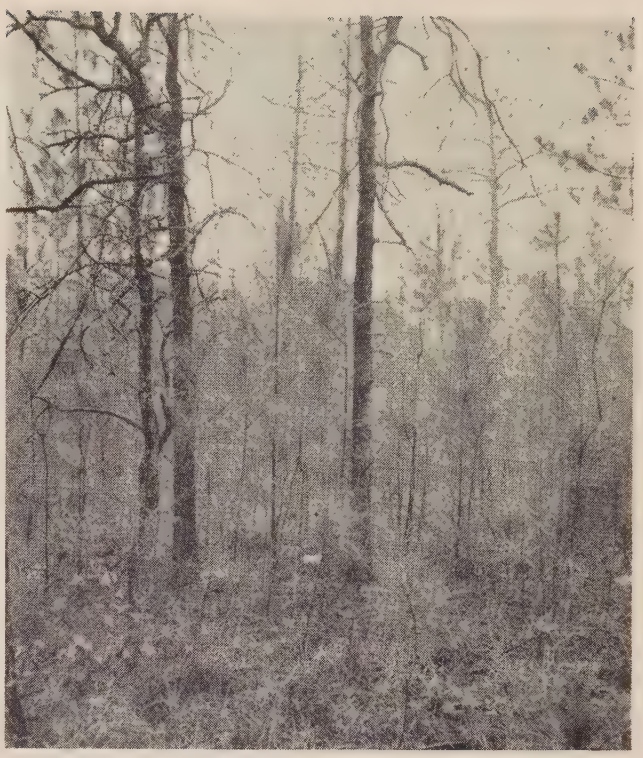

Fig. 7. Natural loblolly pine reproduction released from blackjack overstory by chemical ammate poisoning

Avenue No. 6.—Planting of Nonrestocked Forest Lands: Much might be written about the excellent results obtained on large-scale plantations. There are numbers of them to be seen throughout the South, the largest and oldest being those set out by the old Great Southern Lumber Company in Bogalusa, Louisiana, and added to year after year by the Gaylord Container Corporation. The fine results obtainable have been amply demonstrated. The problem all over the South is to obtain sufficient seedlings to supply the demand for planting on both public and company-owned lands.

The six avenues of attack which have been discussed above are open to every unit in the saw mill and pulp industries of the South. To imagine that the forest resources will remain unimpaired unless we do attack the problem is sheer folly. The pulp mills through the Southern Pulpwood Conservation Association have taken an active lead in this assault. For the lumber industry to join forces is now the crying need. It will not suffice merely to publicize the importance of the respective industries and their contribution to the economic life of the South and of the Nation. The public is now beginning to ask what measures the forest-industries are taking to *keep the forests productive.* If we do not take action, it will not be surprising if the State or Federal Governments step in with regulations which, we may be sure, will be far easier of enforcement against industries than against individuals.

Economics of Wood Handling

JOHN A. WILLARD

This paper deals with the problems of wood handling and the part that mechanization can play in them. The author, from his observations of wood-handling operations in Sweden a year ago, contrasts methods in that country with those in effect here. Throughout the paper emphasis is laid on the importance of knowing costs as the first step toward reducing them. This applies to the wood wherever it is handled, in the woods, enroute or in the yard. Various ways of handling wood are discussed, with reference to the differences in method between the north and the south. It is strongly urged that handling methods and equipment be selected only after careful study and on the basis of preplanning of operating costs. A cost formula is included for guidance.

THIS paper is to deal primarily with the problems of wood handling lying within the responsibility of paper mill personnel as contrasted with the responsibilities of the woods department, whose job is to buy or harvest the supply of wood and deliver it to the wood yard.

Yet it should be borne in mind that these two responsibilities cannot be wholly separated. The delivery problem of the woods department is complicated by the way the mill equips its wood yard receiving facilities; but again, these facilities must be fashioned in accordance with how wood can be or is delivered. The wide variety of handling problems involved can constantly be seen in a broad range of methods of wood delivery: namely, river-driven wood, rail deliveries (with their variations of box cars, flat cars and even gondolas), motor trucks which may be either company-owned trucks, hired trucks, or contractors' trucks), and farm vehicles of sundry kinds.

Primarily and fundamentally, it is necessary here to urge paper mill operating executives to take a more definite interest in the problems of wood delivery than is too often the case at present. Mill managements often are seemingly indifferent to many of the problems involved in determining trucking costs, in eliminating the unnecessary delays which are apt to become chronic in the unloading of trucks or cars in the wood yard, and in establishing fair but accurate methods of scaling or otherwise measuring wood. Of course, there are outstanding examples of interest on the part of mill executives in various aspects of these problems. However, far too often their efforts are not coordinated; far too often they do not cover all phases of the problem; and even more often their interest is sporadic rather than well maintained.

Before proceeding with a discussion of the various elements of the wood handling problem, it might be interesting to digress and make a few comments with regard to a visit to Scandinavia last year. During this visit to Sweden, the opportunity was enjoyed of looking over the woods operations and the wood handling operations of the Uddeholm Company, among others.

It was observed that the problems of forest management were handled extremely well on an operation covering some 750,000 acres of woodlands, of which about 560,000 acres were in active production of pulpwood. The differential between these two figures was made up of land used for roads and the natural occurrences of lakes, rivers, swamps, ledges, or other areas unsuitable for growing pulpwood.

The skillful handling of forest management problems and training in this field was not acquired overnight. It dates back to the many years of growing wood for use in smelting Swedish ore to yield Swedish steels practically free from phosphorus and sulphur (the presence of which in many cases in U. S. steel is primarily the result of using coal or coke for smelting). Accordingly, with the development of the sulphite process by the late Carl Eckman, forests were available for the production of pulp and paper. Furthermore the Swedes knew how to grow these forests and looked upon them as a national crop—with a longer growing season before being ready to harvest than a vegetable garden, but to be just as carefully managed. In general, the impression was gained that about three times the number of trained foresters are used in Sweden per 100,000 acres of woodland as in the U. S.

Whereas the problems of forest management have been highly developed in Sweden, the harvesting of the wood crop and the handling of wood in the woods has not yet been mechanized to anything like the point it has reached in America. Much of their wood is delivered in lengths of 4 to 5 meters. Some logs are peeled in the woods, but many barking drums are being used in the mills, especially in the 5 meter lengths. These logs, of course, are subsequently cut to normal pulpwood length by gang saws in the mill. The growing cycle permits cutting of the average species about once in 35 years, as contrasted with a considerably shorter period in the Southern States. Even then, a great deal of the wood is much smaller in diameter than is economic to cut in America, ranging from 3 to 4 inches only, this despite the fact that woods employees are paid about 75 to 80¢ an hour in Sweden.

Studies which have been carried out in the south in this country show that the fiber yield on trees $6^1/_2$ inches d.b.h. and smaller is not economic. The cost is too high for the fiber yield produced. Trees below $6^1/_2$ inches in diameter should not be cut under a selective cutting program unless the trees are defective or unless it is necessary to "clear cut" a wood lot to

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Fig. 1. Wood sorting booms—storage pockets

improve future growth. No doubt much of Sweden's use of 4 to 5 meter lengths is due to smaller tree diameter than is common in the United States, but it is hard to visualize its being economic even there to cut the smaller trees. The fiber yield from a tree increases with the square of the diameter, in Sweden as everywhere else.

HANDLING WOOD TO THE MILL

Log lengths, however, are economic for river driving even in the United States. Where this method is used it is customary to reclaim the logs from the water by a chain conveyor running down below log level in the water to facilitate conveyor loading. The conveyor then feeds directly to a gang saw for cutting to length.

In rivers which serve more than one mill, extensive sorting booms are necessary. Figure 1 shows such a layout on the Klarälven in Sweden. The logs are assembled in rafts and towed to the mill after sorting. The labor and power cost is at a minimum. Since these logs also have to be sorted by species of wood as well as by ownership, this layout permits doing the job well *once*. The word "once" is emphasized because all to often in wood handling a job is only partly done (as, for instance, when changes in plans cause temporary stacking of wood). Then the wood has to be handled all over again before delivery to its destination. Handling and rehandling wood in the yard is one of the most important causes of excessive yard handling costs. It usually costs from 65¢ to $1.00 per cord to make even the simplest movement of a cord of wood, particularly if handled by hand.

Therefore, planning for a single straight-through handling of wood can result in definitely lower costs. In this statement no criticism is intended of the practice of keeping wood in storage piles awaiting use, because the way has not yet been found to run a mill every day without a reasonable wood inventory, even in the south. The cost of shutting down a paper mill far outweighs the expense of piling and reclaiming wood. Again, in the north the cutting season limitations make storage of wood in large quantities unavoidable.

Before leaving the subject of bucking wood into pulpwood lengths, it might be well to go on record that this operation can be carried out most economically at the mill; that trees should be cut in reasonable log lengths (depending upon the type of tree, the species, and log diameter); and should be skidded to central loading landings and there loaded on pole trucks by an "A" frame loader. The pole trucks would deliver these logs to the mill where the logs could well be dumped on a chain conveyor and fed through a gang saw for cutting to pulpwood length. It is believed the costs of handling wood to the mill in this way will show a definite over-all saving, because the average load per truck is about doubled while handling and trucking costs are lowered.

A familiarity with proper methods of figuring trucking costs* is essential to the mill management. With such data the yard arrangements can be laid out to minimize truck "turn-around" time and delivery costs. The importance of this cost reduction can be presented to the management in dollars and cents. Put that way, the figures attract attention. Costs are separated into fixed per hour costs and operating per hour costs.

The way in which doubling the load on a truck can reduce costs will immediately be seen from the cost formula. Loads and speeds depend on road conditions and truck design. Even when tires are not rationed, trucks should never be run through the woods to pick up wood. It is uneconomic. Trucks should stay on reasonably well made roads. Use of the cost formula will determine how much can be afforded to spend for roads.

UNLOADING WOOD AT THE YARD

The development of adequate methods of unloading wood at the mill yard has probably been retarded as much as any other one phase of wood handling although numerous attempts have been made to correct that fact. The operation is dependent mainly on day labor in far too many instances.

As stated in an earlier section of this paper, wood arrives at the yard in motor trucks, farmers' wagons, box cars, flat cars, sometimes by gondolas, or by water. In the latter case, it can arrive either floated or on barges.

For the unloading of trucks, costs can be very greatly reduced if large dump trucks can be used. Where the variety of trucks to be handled at the yard is very wide, it is suggested that an inclined ramp be installed with provisions for blocking the wheels so that gravity will have a chance to do the greater portion of the work in unloading the truck after the binding chains or ropes are taken off.

In all probability, only the mill owners can afford to own dump trucks. Private operators and contractors would be much more apt to have platform trucks which could make good use of an inclined unloading dock.

In each particular case a fundamental job should be carried out on studying delivery conditions at the mill, and so far as possible unloading of trucks by hand labor should be reduced to a minimum.

* A brief but adequate statement of how to figure trucking costs can be found in "Preplanning of Logging Operations for Minimum Costs," by Don M. Matthews and J. A. Willard, published in *Mechanical Engineering*, May, 1945; *Paper Trade J.* 122, No. 6: 43-47 (Feb. 7, 1946).

On wood received by rail, it is understood that the Bangor & Aroostook Railroad has recently developed a box car whose sides are hinged at the top so that the box car load can be dumped quite quickly on arrival at the mill, or at least within the demurrage period. It has been stated, however, that some other railroads think that the possibility of these sides working loose while in transit constitutes a menace to safe railroading.

In Sweden cases were observed where flat cars were switched onto a side track that had one rail lowered 4 or 5 inches below the other rail. Thus when the side stakes were pulled out and the binding chains released, the whole load rolled off the side of the car at minimum cost. The author has tried to convince American mill operators that this is a good scheme, but he has never seen it adopted in this country, though of course it is possible that it is being used in some isolated instances (see Figs. 2 and 3).

Again, the idea has been advocated of using a ram or pusher working through the side door of a box car to move out the center loaded section of the car. So far as is known, however, in 10 or 15 years' time this scheme has not gone beyond the drafting board stage. This is probably because the attention of mill management has tended to be concentrated on operations within the mill rather than because of any defect in the idea itself.

Orange-peel grab buckets have been quite widely used in unloading flat cars and for reclaiming wood from ground piles or for other storage. Here again a careful calculation of handling costs should be made before the equipment is purchased.

These types of cranes and buckets constitute a substantial investment and their fixed costs, plus their per hour operating costs, need to be gone into with care ahead of time, rather than after excessive costs are encountered. These statements should not be taken as a criticism of this type of equipment where it has been carefully selected with a full knowledge of the operating costs involved.

Again, some mills, particularly those where the wood comes in on barges, have been able to make worth-while savings by arranging for the wood to be put up in bundles and handled with slings and cranes. This type of operation is very much more apt to be economic than the use of an orange-peel where the

Fig. 2. Car unloading—one depressed rail—end view

Fig. 3. Car unloading—one depressed rail—delivery side

load per trip of the crane boom is variable and dependent upon the accidents of pile arrangement.

For a comparison of the costs of these various methods of wood handling as against unloading a box car by hand labor, studies have shown that the standard rate of unloading a box car by hand will average about 3 units per man-hour. In this case the unit contains 160 cubic feet of wood. The average diameter is $8^1/_2$ inches for rough wood. Peeled wood can be handled a little faster, unless the sap has not dried out of the wood, probably because it is easier on the hands than rough wood. Some individual studies have shown an unloading cost (in man-hours) of double that given above, in cases where the wood averaged so large in size that it could not readily be handled with a smooth motion.

Studies of unloading trucks by hand, containing roughly $1^6/_{10}$ to 2 units per truck, show an average of about 25 minutes. Unloading of the same size truck by tilting took from 1 to 3 minutes.

Further studies of the gain to be made in unloading box cars by tipping indicate savings of approximately 30%.

The units that can be handled per trip of an orange-peel bucket range from $^1/_2$ to $^3/_4$ of a unit. At 40 trips per hour, the cost per unit to reclaim wood by orange-peel is approximately 21 to 30¢ per unit.

Any of these figures for output, measured in time, can be multiplied by present-day wage rates to determine present-day cost. The cost for using an orange-peel bucket is about 3 years old and today's figure should be adjusted accordingly.

WOOD HANDLING AFTER ARRIVAL AT THE YARD

At most mills in the north, wood is peeled either in the woods or before being put into storage piles at the mill.

In the south; wood is peeled almost exclusively in barking drums at the mill. The peeling of the wood is not carried out until the wood is put into process; it goes through barking drums on the way to the chip house.

In the south, if wood stays in storage piles more than a few months, bugs will bring about the peeling with some deterioration of the wood.

Therefore, the handling of the wood in the yard

will depend a good deal upon whether the mill is located in the north or in the south and how many different kinds of wood are necessary for the types of paper produced at the paper mill.

In a typical mill located about half way between the north and south, one is very apt to find four kinds of wood that have to be handled. The wood classification in the wood yard is not necessarily the same classification that is used in the woods. At the mill a wood is rated as "hard" or "soft" by the length of cooking time in the digester rather than on the basis of tree technology.

As an example of the problems that can occur in a single wood yard handling a number of different kinds of woods, the following list gives some of the items that had to be considered in working out the design of wood yard facilities:

1. Bark all wood before piling in storage.
2. Four kinds of wood to be handled and kept separately, about 50% short leaf pine.
3. Barking drum capacity twice as great on pine as on hardwood.
4. Sort for cleanliness.
5. Sort for size (14 inch maximum to chipper).
6. Practically all car receipts in box cars, hand unloaded.
7. 15% of total by truck (2-cord capacity).
8. Ability to unload several types of wood simultaneously without mixing.
9. Ability to reclaim from pile while unloading from cars.
10. Opportunity to take out first, the first wood in.
11. Avoidance of night operations if possible.
12. Reclaim by orange-peel bucket 85% of pile in one handling.
13. Central control of operations to promote safety of personnel.

No attempt will be made to detail the actual design laid out to meet all these conditions because they probably would have to be handled differently somewhere else. There is more than one way of dealing with several of them.

The method which is most commonly met in the south is to dump or throw the wood into some type of drag chain conveyor, with high maintenance cost inherent in such procedure.

All kinds of variations have been seen in handling and storing the incoming wood. In some cases use is made of multiple spur tracks for rail delivery of wood to storage piles; in other cases a multiple system of roadways is used for piling direct from trucks into storage piles. Again, provision has to be made for delivery of wood direct to the barking drums so that in case of shortage of some types of wood, incoming wood either by truck or by car can be conveyed straight to the barking drums and thence to the chip house.

Also, in northern mills when wood is not peeled in the woods, provision must be made for sorting for cleanliness after it comes from the barking drums. This could mean either sending wood back to the barking drums for another cycle, or to storage piles, or to the chip house.

Practically anything that is stated in this paper with respect to barking drums would apply also to the hydraulic barker, although in a large number of cases wood goes directly into process from hydraulic barkers rather than to storage piles.

There has also been seen in the south a wood yard laid out with a network of drag chain conveyors for reclaiming the wood from piles. On account of the high maintenance cost, it is believed that this method is suitable only for a relatively small storage volume where the turnover of wood is high and where weather does not interfere with year-round woods operations.

As has been referred to previously, water-borne wood is used extensively in the north but to a very limited extent in the south. Where this method is used, periodic reclamation of wood that will not float is usually economic. A velocity of 3 or 4 feet a second will serve to keep hardwood "sinkers" moving and minimize this reclamation cost.

Undoubtedly, the first cost of concrete flumes or sluiceways may be substantially higher than that of drag chain conveyors, but certainly the maintenance cost of the former is substantially under that of cable and button drags or link chains.

It is believed that in the next two or three years sufficient comparative cost experience will have been developed to permit a sounder appraisal of the types of conveyor methods used in handling wood from its point of receipt, either to storage or to the chip house.

The method of delivering the wood from the barking devices to the storage piles will depend a great deal upon the location of the mill and the amount of wood stored compared with mill capacity.

The harvesting of wood in locations in the mid-Atlantic area requires that a third of a year's supply be on hand at the end of a cutting season. In mills further north, even more than this is needed, and the problem of piling this wood, and its recovery from the piles, can become a substantial factor in wood yard handling costs.

An impressive overhead conveyor of the cable and button type was observed in operation at Grande Mere, Quebec. It resulted, of course, in jackstraw piling and permitted recovery either through feeding gates, where the conveyor went underground on its return, or from the sides of the pile if that were desired. This particular conveyor was relatively simple, having towers about 80 feet high and perhaps 200 feet apart. For a considerable portion of the distance between the towers, the cable was unsupported, merely leveling off the top of the pile when it rose too high.

Experience has shown that button spacing on a conveyor of this sort should be 5 to 6 feet depending upon the length of the wood, and that relatively large bull wheels at the end make for lower maintenance.

This type of overhead conveyor, with a cable about 80 feet high, permits making piles about 200 feet wide. This capacity can be increased if some of the stored wood is hand ranked at the edges of the pile. In some locations the contour of the ground might make construction of permanent retaining walls desirable. Piles of this sort will hold, roughly, 20,000 to 23000 cords of wood.

Figure 4 shows a rather deluxe edition of this type

of overhead conveyor with a suspension bridge design which is considerably more expensive than the conveyor seen at Grande Mere, Quebec.

Alternatives to this type of overhead conveyor are the inclined boom stationary pilers that are fed by drag chain conveyors from a barking drum, truck, or freight car. In cases where peeled wood is received, pilers of this sort have been used quite effectively in combination with drag chain conveyors, though the maintenance cost is relatively higher.

It should be pointed out here that in the case of the overhead conveyor the only reason for using orange-peel buckets for reclaiming of the wood instead of the return side of the conveyor in a tunnel, would be because of the necessity of keeping the different kinds of wood separate. As stated earlier, orange-peel reclaiming can probably be done for 21 to 30¢ a cord, and alternative methods should be kept within these limits unless the design characteristics, which have to be met, make it necessary to resort to some other method, even if more expensive.

One mill has an arrangement of three barking drums with facilities for sorting the wood after barking and delivering it either to the storage piles or to the chip house or for recycling through the drums.

In all probability the ideal method of peeling wood has not yet been developed. The barking drum manufacturers are still seeking a design of drum that will stand up under the pounding of heavy wood and at the same time remove the bark efficiently. In the last 3 or 4 years considerable improvement has been made in drum design both with respect to ability to get the bark off and in reducing maintenance cost of the drum itself.

The hydraulic barker has been adopted by quite a few mills for at least a portion of their barking, but with its relatively greater cost per cord than the barking drum, it has not yet provided the whole answer to this difficult problem. However, in view of the high cost of wages per hour in the woods, it is imperative to use some means of barking the wood other than by hand.

The problem of bark disposal is an important one, which receives too little consideration from mill management. In the newer Southern mills, engineered from the start, adequate provision is usually made for burning the bark for steam generation. While bark is thinner on northern trees, adequate means for drying out and burning the bark should return a good profit on the necessary equipment.

One idea which it is believed has not been tried to any extent, in connection with the storage of wood and the providing of facilities to make possible a multiplicity of methods of handling, would be that of providing sizable bins for the storage of chips.

To store a unit of 160 cubic feet of pulpwood, loosely piled, takes from 215 to 230 cubic feet. To store the same unit in the form of chips would take about 300 cubic feet. Thus, almost double the cord capacity (piled wood) must be provided for chip storage. However, a relatively modest chip inventory might well be a factor in permitting more simplified operation of a wood yard where three or four different kinds of wood have to be handled and it is desired to minimize the amount of barking and handling equipment to be supplied for simultaneous operation.

Fig. 4. Overhead cable and button jack straw piler

Such a plan might easily permit a more distant location of the chipper house from the digester building and in some cases serve to solve difficult plant layout problems set up by the location of water supply, uneven ground, or other factors.

Throughout this discussion emphasis has continually been laid on the necessity for a predetermination of operating costs. Take as an example, a wood yard handling 700 cords a day. To meet design conditions similar to those mentioned earlier in this report, it has been possible to operate such a yard with a normal crew of 6 men around the equipment and 10 more at various stations in the yard. In the selection of wood handling methods the man power required is calculated to reduce handling costs to a minimum.

THE COST FORMULA

The cost formula referred to previously is not complex. In general, in calculating the desirability of a particular method involving the use of mechanized equipment, costs will be at a *minimum* when the fixed costs per hour approximately equal the variable operating costs per hour. That is why they are termed "economic costs."

Fixed costs include those items that are incurred even though the equipment is not operating steadily. They are: interest on investment, depreciation, insurance, taxes, standby labor, social security, proportion of general yard overhead expense, and licenses—motorized equipment.

Operating costs per hour run are: power (electric or gasoline and oil and grease); repair parts (particularly on chain conveyors); repair labor (tires on motorized equipment, etc.); operating labor, on average run time when labor goes to operate other equipment during shutdown period.

Calculate the anticipated hours of operation per year and assume the fixed and variable costs per hour are equal. When so arranged minimum costs will result. It can then readily be figured whether the investment is justifiable. Or one can calculate the cost per cord of wood and compare it with other methods or even with hand labor.

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Microstructure of Wood and Wood Fibers

GEORGE J. RITTER

The object of this paper is to indicate the phases of wood and fiber microstructure that should be considered in the light of current developments. The structure of wood and its various components are described in considerable detail.

THE work of early investigators on the microstructure of wood and wood fibers serves as a stimulus to present-day research workers. Although early microscopes were crude, in comparison with those of present-day design, in the hands of careful workers they did disclose extremely fine microstructures in wood and the cell walls of fibers. Fibrils were reported in the cell walls of fibers by Meyer in 1838 (*11*). Stratification in transverse wood sections and striations in the lateral surfaces of fibers were recorded in 1877 and 1882 (*24*). Nageli's micelle theory of plant structure (*13*), which is still fundamentally sound, was published in 1877. Treatment of fibers in 1892 with acid at elevated temperatures transformed the material to a dustlike residue, the particles of which were designated dermatosomes (*26*).

During the last 25 years several research workers developed methods for locating the chemical constituents in the cell wall. Wood sections were treated with solvents for a given constituent and with the aid of a microscope the position of the remaining constituents was located in the residue. Some preliminary work in this field (*1, 9*) showed the possibility of obtaining fundamental data on the cell-wall structure. A series of publications (*2, 3, 5, 7, 10, 11, 16, 23, 25*) has furnished many confirmatory data and some of a contradictory nature.

The object of the present paper is to indicate the phases of wood and fiber microstructure that should be considered in the light of current developments.

Microstructure in conjunction with the chemical composition of wood should be considered in the development of commercial uses for the material. For example, the fact that wood is composed of slender fibers and that the fibers can be separated mechanically and chemically is the basis for the development of processes for converting wood to pulp. Further, the fibrous-porous nature of wood is the basis for methods of impregnating it with preservative liquors.

Although wood substance, that is, material comprising cell walls, has a constant specific gravity of approximately 1.5, the porous structure reduces its over-all specific gravity to values that range, because of variation in size of cell cavity and cell-wall thickness, from approximately 0.3 to 0.8, averaging about 0.5.

Since the specific gravity of wood substance is 1.5 and that of the over-all wood averages 0.5, approximately two-thirds of a wood block comprises air interstices or pockets containing air.

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Due to its over-all porousness and lightness and its strong affinity for water, wood is easily sawed, cut, planed, shaped, steamed, bent, plasticized, molded, and fabricated. It can be fabricated on the job into intricate structures with simple tools, and firmly held in place by nails, screws, or adhesives.

CONVENTIONAL PLANES OF WOOD

Conventional terms descriptive of the planes in which wood is cut for study are used throughout this discussion. A wedge-shaped specimen in Fig. 1 sawed from the trunk of a tree serves to illustrate each plane. As shown in Fig. 1, the face resulting when a bolt of wood is cut crosswise at right angles to the grain is called a cross section or transverse section. The radial face is exposed when the wood is cut at right angles to the transverse face and follows a radius of the bolt. The tangential face is exposed when the wood is cut parallel with the grain, at right angles to the radial face, and parallel to the annual rings.

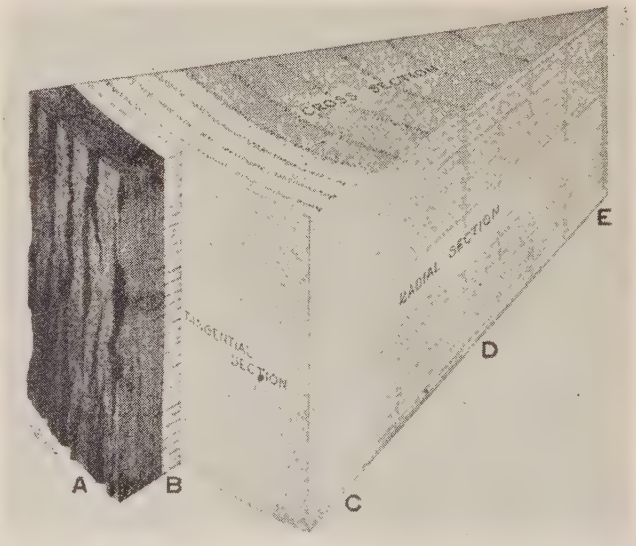

Fig. 1. Wedge of wood

In hardwoods the fibrous elements comprise fibers, parenchyma cells, and vessels in the longitudinal direction and ray cells that are the elements of the wood rays, in the horizontal direction of the tree, as shown in Fig. 2. The walls of the fibers are copiously perforated with pits. These pits are much more numerous on the radial than on the tangential walls. The walls of ray cells are also copiously pitted and where a vertical fiber crosses a ray cell, the pitting is conjunctive. Thus communication between fibers, between ray cells, and between fibers and ray cells is provided in the radial direction. In softwoods the fibrous elements comprise tracheids and resin ducts in the longitudinal direction and ray cells in the hori-

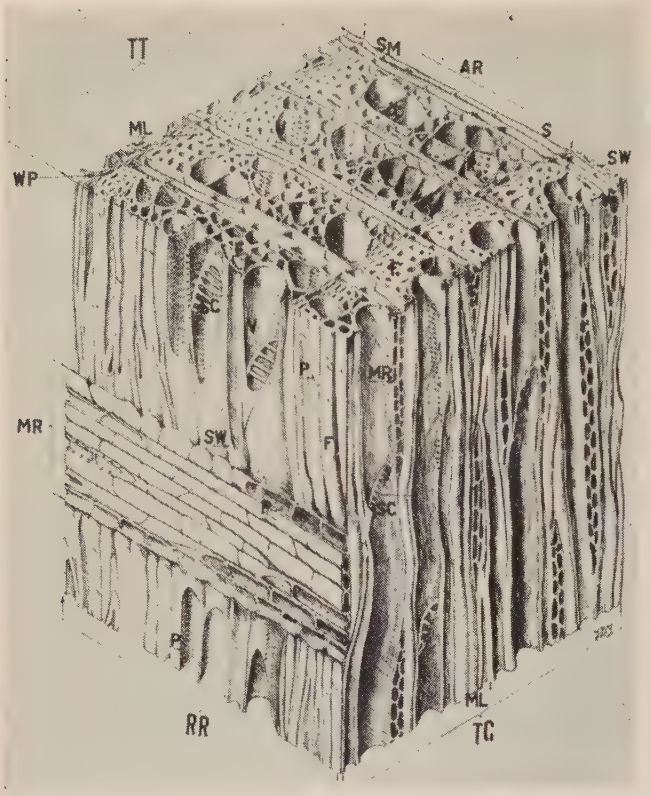

Fig. 2. Diagram of hardwood block

zontal direction. Horizontal resin ducts are also present in the wood rays of pines, tamaracks, Douglas fir, and spruces, as may be noted in Fig. 3. Pits that copiously occur on the radial walls of the fibrous elements provide communication between adjoining tracheids, between ray cells, and between tracheids and ray cells.

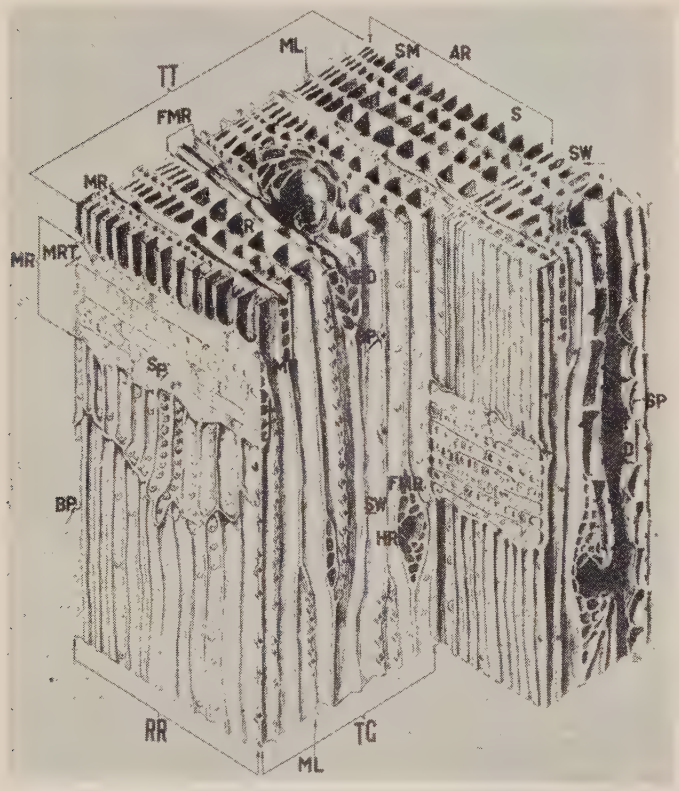

Fig. 3. Diagram of a softwood block

The wood specimens in Figs. 2 and 3, as may be noted are heterogeneous in structure; they are also heterogenous in chemical composition, comprising extractives, ash-forming minerals, lignin, and holocellulose. However, the last three of the four preceding components are uniformly diffused throughout one another in a macro sense so that any one of the three components by itself retains the microstructural pattern of the wood, as has been demonstrated by Ritter (*17*). He removed the extractives from wood blocks cut $^1/_8$ inch on edge. From one of the cubes he removed the lignin with a lignin solvent, leaving the holocellulose as a cubical block, which retained the microstructural patterns of the wood (Fig. 4a). Retention of the wood structure by the holocellulose is apparently possible because a portion of the hemicelluloses in the holocellulose is located with the lignin in the middle lamella and thereby holds the holocellulose cells together. A second extractive-free block was treated with solvents that dissolve the holocellulose and the ash-forming minerals, thereby leaving the lignin residue which retains the microstructural pattern of the wood because lignin is present in the cell wall and the middle lamella as shown in Fig. 4c. A third extractive-free block was burned in an atmosphere of partially ozonized oxygen in a carefully controlled electric furnace to remove all the organic materials of the wood. The ash block weighed 0.4% of the extractive-free wood and retained the microstructural pattern of the wood, as shown in Fig. 4d, indicating that the ash-forming minerals are distributed in the cell wall and the middle lamella. Figs. 4a′, b′, c′, d′ show the cross-sectional pattern of the blocks of extractive-free wood, holocellulose, lignin, and ash.

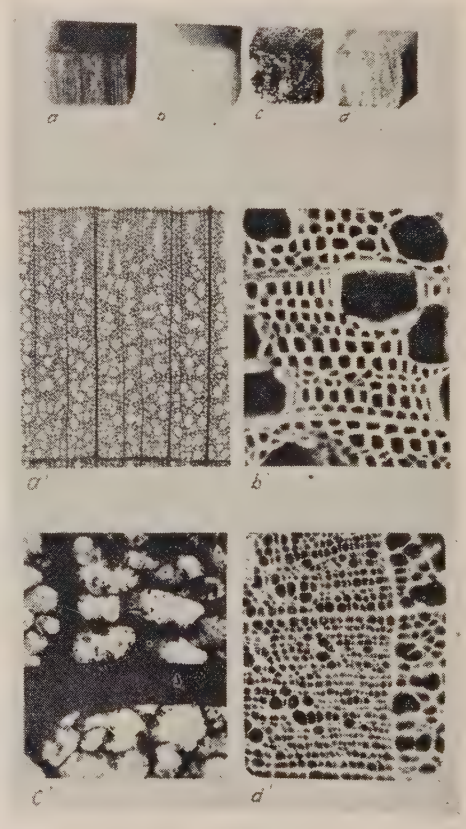

Fig. 4. Components that retain the microstructure of the wood

EXTRACTIVES

Extractives include tannins, sugars, starches, oils, resins, fats, and waxes, and are soluble in neutral solvents, such as water, alcohol, ether, benzene, and acetone. They are sometimes referred to as incrustants occurring in the cell cavities, the intercellular spaces, and the cell wall, but they form no part of the wood structure. Although extractives are described as soluble in neutral solvents, some of them in heartwood appear to polymerize or otherwise react to form exceedingly refractive materials to neutral solvents; they even become insoluble in lignin and holocellulose solvents. A paper on membranous substances in heartwood by Pew (*14*) to appear in the *Journal of Forestry* shows that refractive extractives occur in the ray cells of the heartwood from Douglas fir, hemlock, oak, and spruce. They can be isolated by dissolving the lignin and the holocellulose by means of a formaldehyde-sulphuric acid mixture, thereby leaving the resistant extractives as thin liners of the original ray cells even to the extent of liners of the ray-cell pits as shown in Fig. 5.

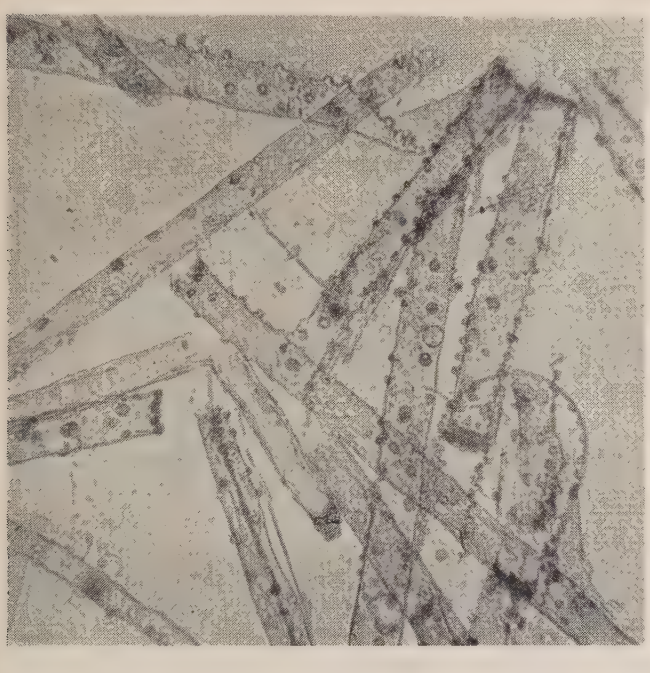

Fig. 5. Liners of extractives in ray cells

When any of the components are extracted from wood, the residue increases in porosity through the creation of artificial voids. These voids supplement those of the permanent class known as fiber cavities, intercellular spaces at the junction of three or more fibers, and the transient voids between cellulose crystallites, and between amorphously arranged cellulose chains into which water is adsorbed to cause the swelling of wood. Ritter has demonstrated that the artificially created voids become microscopically visible if sufficient percentages of the extractives, hemicelluloses, and lignins are removed by solvents as shown in Fig. 6 in which loosening of the cell wall to show stratification has begun. If the removal of cell-wall components is carried further, separation of the sleeves to disclose stratifications of the cell wall and loosening of tertiary cell-wall fibrils begin as shown in Fig. 7.

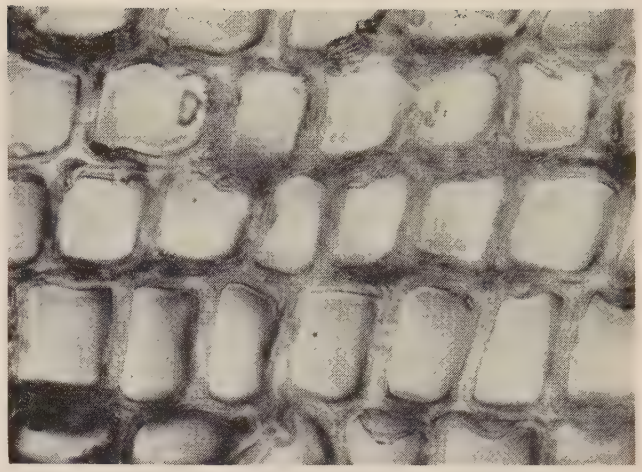

Fig. 6. Cross section of softwood from which extractives and some of the hemicelluloses have been removed

The removal of portions of the cell-wall components weakens the walls, makes possible further swelling of the softened tissues, and produces slight deformation of the fiber cross sections from general rectangular to ring shape, because fiber sections are swollen beyond their original water-soaked conditions, they change to the shape requiring the least external surface.

MICROSTRUCTURE OF FIBERS

Sleeves

Wood fibers are slender hollow capsular-shaped bodies. Fibers from hardwoods average 1 mm. in length and 0.01 mm. in diameter; those from softwoods average 3 mm. in length and 0.03 mm. in diameter. Wood fibers have been reported as comprising a microstructure resembling concentric sleeves which first manifest themselves as stratifications. The sleeves of delignified wood fibers can be loosened by chemical means and separated (*18*) from one another by telescoping them endwise.

Fibrils

Except for the numerous pit apertures, the outer sleeves of well-delignified fibers, before being subjected to chemical dissecting agents, appear as slender, pointed, smooth-surfaced homogeneous capsules. How-

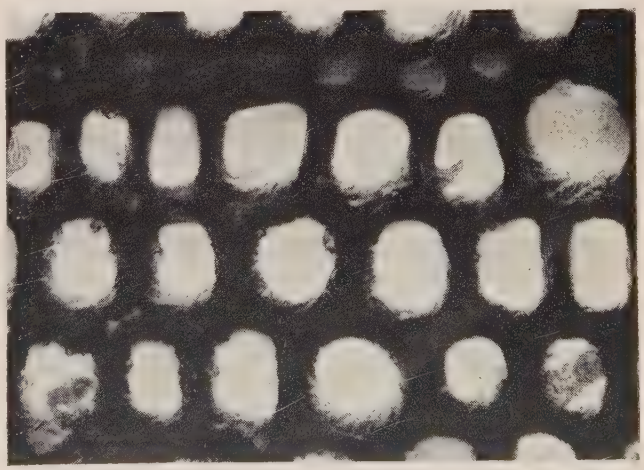

Fig. 7. Cross section of softwood in which the fibrils in the tertiary layer have been loosened

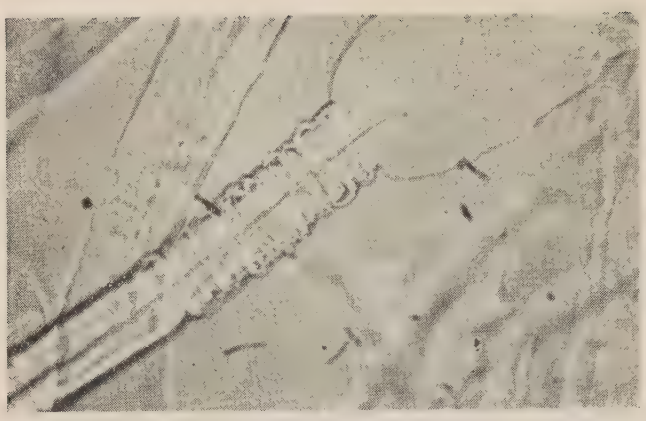

Fig. 8. Striations of the outer sleeve

ever, after basic and acidic chemical dissecting agents are applied, striations develop in the transverse direction. Continued application of the dissecting agents discloses that the sleeve is actually composed of cellulosic filaments called fibrils (*18, 19*) which are wrapped around the inner concentric sleeves at approximately 90° to the longitudinal axis of the fiber as in Fig. 8. Further evidence of its fibrillar structure is indicated when the outer sleeve is removed and slightly stretched as shown in Fig. 9.

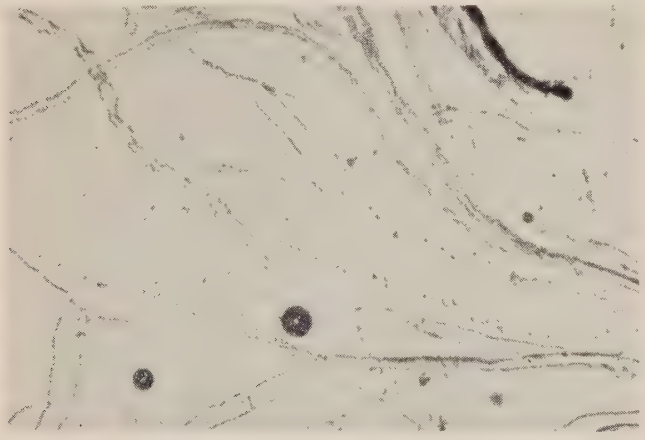

Fig. 9. Outer sleeve of fiber removed and slightly stretched

The outersleeve helps to retain the shape of the fiber by restraining swelling transversely beyond the water-soaked condition. This function is disclosed by a beadlike appearance of fibers treated with alkali agents that dissolve the outer sleeve from restricted areas and allow bending of inner sleeves alternately with the restrictions where the outer sleeve is intact as in Fig. 10. By rupturing a constriction mechanically, the two adjoining beads form one large bead as shown in Fig. 10.

Ritter has demonstrated that mechanical abrasion of fibers produces a vulnerable point of attack for chemical reagents. He subjected short segments of delignified wood fibers to the action of 10.0% aqueous sodium hydroxide solution. The reagent began solubilizing the outer sleeve at the cut ends of the segment and progressed slowly toward a point intermediate to the two extremities. Before the solubilizing effects from the two ends met, the reaction was arrested. The resulting fiber segments with their broom-shaped ends resemble a bundle of grain as in Fig. 11. It discloses

Fig. 10. Beading effect of wood fibers

the catalyzing effect of mechanical abrasion, the restraining action of the outer sleeve to transvere swelling of the fibers, and the extreme transverse swelling property of the inner sleeve.

Other causes for the beading of fibers have been published. Trogus (*25*) explains the development of crosswise striations and beading on the basis that the outer sleeve is a homogeneous sheath. It ruptures when drastic swelling agents are applied to the fiber, thus allowing the inner layers of the fiber wall to balloon through the breaks. The swelling pressure so exerted slides the outer sleeve endwise and forms crosswise folds. His explanation appears plausible except for the fact that it does not account for the possibility of unwinding of the outer sleeve as demonstrated in Fig. 9.

Skin Substance

Ludtke explains the crosswise constrictions and beading of fibers by referring to a material, which he calls skin substance, of unknown composition. His theory is that the wood fiber is divided into cross

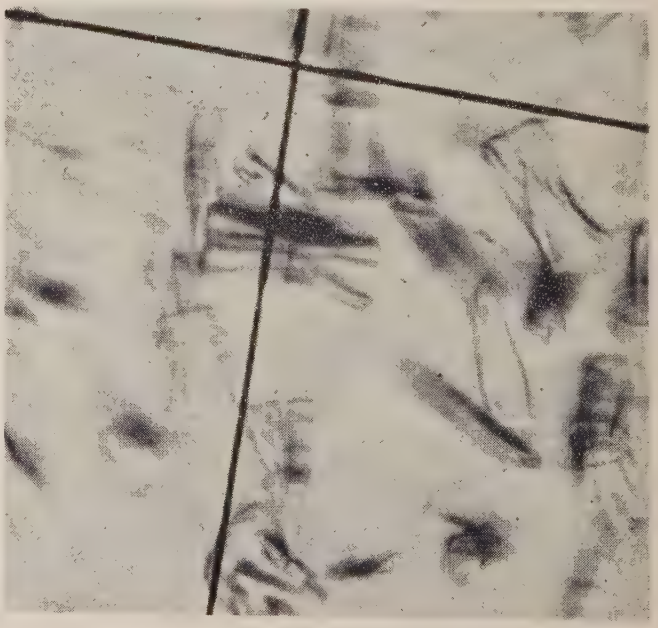

Fig. 11. Short segments of fibers from which outer sleeve has been partially removed

sections or segments by double cross walls of the skin substances at intervals of 40 to 60 microns. The segments are also sheathed over the outside and inside lateral walls with the skin substance, which is grown to one of the cross walls at each end of the segment, thereby sealing off the cylindrical segment from the two adjoining endwise segments. Thus, when the delignified fibers expand transversely on being subjected to drastic swelling agents, the cross walls restrain transverse expansion, whereas the thin skin substance covering the segment between the cross walls fails to restrain the transverse swelling pressure that produces the formation of beads.

Ludtke postulates further presence of the skin substance. Not only is each fiber segment coated inside and outside and endwise with skin substance, but each concentric cylindrical sleeve of the fiber segments is likewise coated inside and outside with the skin substance and, still further, the skin substance forms the housing for encasing each of two tiny substructural units of the cylindrical sleeves. Ludtke refers to the larger of the two substructures as fibrils which are 40 to 60 microns long, being limited by the distance between the cross walls. The smaller of the substructures he designates dermatosomes; they are dustlike in dimensions.

If one were to probe, according to Ludtke's theory, (*12*) from the outer surface of a fiber into a dermatosome to reach pure cellulose, it would be necessary to pierce the skin substance covering the outside of the fiber, the skin-substance covering of the sleeve, the skin-substance covering of the fibrils, and finally that of the dermatosome. He states that skin substance is difficult material to remove in the chemical refinement of cellulose. During oxidative chemical refinement of cellulose, the reactive groups of the skin substance are converted to carboxyls. He then assumes the molecular weight of the oxidized skin substance to be 200. Titration of the carboxyl content of the material indicates that the skin substance is equivalent to approximately 3.0% of the wood fiber. This value approximates the percentage of polyuronide carbohydrate, a material of which the sixth carbon of a hexose anhydride is carboxylated. Ludtke's idea, then, regarding fibrils differs from that of Ritter, in that he contends that the fibrils range from 40 to 60 microns in length (the distance between cross walls of the fibers), are coated with skin substance, and are composed of dermatosomes as building units. Ritter, on the other hand, believes fibrils are unlimited by

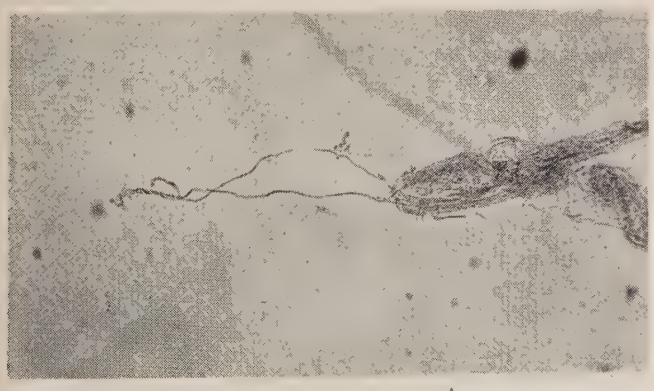

Fig. 12. Fibril teased away from fiber segment

Fig. 13. Fibrils loosened in the inner sleeves of fibers

cross walls since they have been isolated in lengths of 230 microns as shown in Fig. 12; they are surrounded by hemicelluloses and are composed of fusiforms which are slender spindle-shaped doubly refractive structures.

Orientation of Fibrils and Their Substructures

Mention has been made that the fibrillar arrangement in the outer sleeve is approximately 90° to the longitudinal axis of the fiber and that of the inner or tertiary sleeve adjacent to the fiber cavity is approximately 80° to the long fiber axis. However, in contrast, fibrils of the intermediate sleeves of the secondary fiber wall are oriented more nearly parallel, 5 to 30° to the longitudinal fiber axis as shown in Fig. 13. Also, the fusiforms are oriented, in general, parallel with the long axis of the fibrils, as may be demonstrated by means of a polarizing microscope. They are aligned with a slight overlapping of their pointed ends to form the fibrils and are doubly refractive to light between crossed nicol prisms.

Fusiforms were divided by means of strong phosphoric acid into still smaller structures named spherical units (*19*). From the sharp angles of minimum and maximum luminosity of the fusiform, their substructures should manifest parallelism in crystalline arrangement. However, the isolated spherical substructures of the fusiforms were uniformly luminous in all positions between crossed nicols, indicating a random arrangement of their crystalline structure. The disarrangement from parallelism to randomism in the crystalline structure of the new substructural units would result during their isolation in phosphoric acid which is a strong swelling agent.

A means has been developed during the last year by which it is possible to disperse the fusiforms into tiny oblong substructures without the transformation to speroidal units. The disclosure of the procedure involves microscopical observations of different stages of the acetylation of cellulose fibers and the dispersion of the acetylated product in the esterifying medium

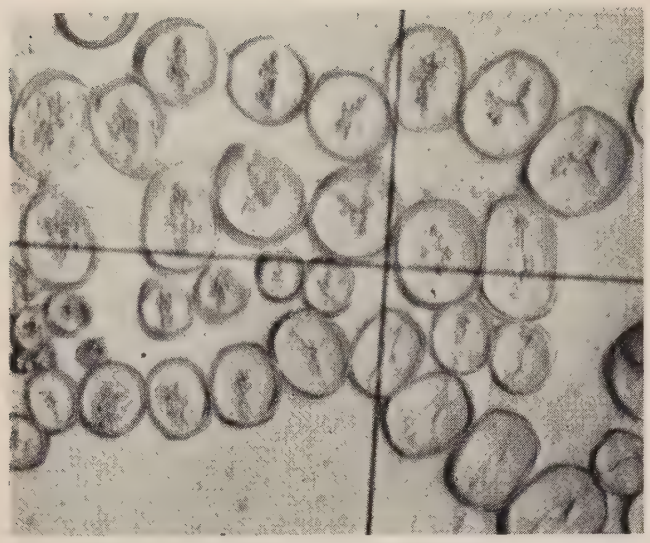

Fig. 14. Cross section of delignified fibers swollen in dilute alkali

whereby the fusiforms are transformed into oblong substructures before complete dispersion occurs.

The fibrils in the outer sleeve of delignified fibers appear to influence tremendously the type of deformation manifested by cross sections of delignified fibers when swollen beyond their water-soaked volume. It appears that the fibrils resist stretching beyond their water-soaked length. As a consequence the angular cross sections assume a circular shape when alkali is used as the swelling agent as in Fig. 14. If the outer wrapping withstands the swelling pressure the cell wall is forced inward, thereby closing the lumen, in which case any restraining action that might be exerted by the tertiary sleeves is overcome. On the other hand, if the restraining action to swelling toward the periphery were absent, the swelling action would proceed outward and the lumen would increase in cross-sectioned area.

FORMATION OF CRYSTALLINE STRUCTURE OF FIBERS

Some work (*20*) has been done on the rate of development of the crystalline structure of wood fibers. Extreme difficulties are encountered in developing a method for accomplishing the objective. One is devising means for selecting and isolating fibers of known age for the test specimen from a living tree, and another is to develop a method for determining which fibers have fully developed crystalline structure.

The procedure which was used for selecting fiber specimens is based on the alignment of fibers in softwoods. As new fibers develop they form successive concentric layers of wood and thereby increase the diameters of the tree.

If a small cross section of softwood on which the bark is intact is examined with the aid of a microscope, it will be noted that the tracheids are arranged in rows in two directions at approximately right angles to one another. In one direction the rows approximately parallel the cambium and in the other, the wood rays. In small cross sections in which the tracheids are properly aligned in the two directions, it seems reasonable to assume that the tracheids in a given row paralleling the cambium are of the same age; and the age of the tracheid increases in the consecutive rows from the cambium toward the pith of the tree.

Cubical blocks 0.5 inch on edge with the bark intact were removed daily for several months from the trunk of a white fir tree 12 inches in diameter. With the aid of a microscope the number of cell rows between the cambium and the preceding year's summerwood was estimated on cross sections cut from the series of blocks. In this manner the ages of the tracheids rows were determined from the time the first block was removed. Next the radial width of the tracheids in the various rows was measured. Then, by means of a microtome, tangential sections of the proper thickness were cut from a block beginning in the bark and proceeding consecutively through the cambium and into the xylem. In this manner, consecutive sections of tracheids, 1, 2, 3, 4, etc., days old were prepared.

The rate of crystal formation was determined by x ray diffraction technique. The tracheids in the sections 1 to 4 days old produced a diffuse ring pattern; those 10 to 12 days old gave a preferred orientation with intensity maxima which were identical with those produced by older tracheids.

CRYSTALLINE ARRANGEMENT IN RAY CELLS AND FIBERS

The crystalline arrangement in the ray cells differs from that in the fibers of basswood according to microscopical examinations of the two types of cells in polarized light (*21*). The significance of this difference lies in the fact that if the difference is found to exist in other species, it will require a modification of the present explanation for the directional shrinking and swelling of wood.

The predominant crystal arrangement of wood fibers as obtained from x ray data (*4*) is located in the secondary cell wall and is, on the average, approximately lengthwise to the long fiber axis. At the time this work was done, no data had been published on a subordinate crystal arrangement that occurs in the thin outer layer of the secondary wall. Microscopical measurements have proved that swelling caused by the adsorption of water manifests itself almost entirely in the crosswise direction of isolated fibers (*22, 8*). No previously published results were available on the crystalline arrangement or the swelling properties of ray cells. Accordingly, the crystal arrangement and the swelling properties of the ray cells from basswood holocellulose were determined in order to compare them with the corresponding properties of the fibers. Briefly, the results showed that the crystallites are arranged crosswise in the ray cells, which is longitudinally in the tree and parallel with the crystallites in the fibers. Thus the ray cells should swell in their lengthwise direction which is the radial direction in the tree. Accordingly, the conventional statement that ray cells do not swell lengthwise and therefore tend to withhold wood from swelling in the radial direction is incorrect.

Confirmation that ray cells swell in the radial direction of wood was demonstrated by microscopical measurements of the cells in their oven-dry and water-soaked condition, which showed 3 to 4% swelling from the oven-dry condition (*21*).

Still further evidence that ray cells will swell in the radial direction of the wood is furnished by x ray data (*6*) revealing that their cellulose crystallites are arranged in the general crosswise direction of the ray cells.

So far, then, data obtained by means of the polarizing microscope and the x ray-diffraction technique indicate that ray cells would shrink and swell longitudinally during the sorption of waters; and swelling measurements made on isolated ray cells in their oven-dry and their water-soaked condition show that they do swell longitudinally. Therefore, the statement that ray cells like fibers do not swell longitudinally, which is based on analogy only, is in error.

To submit experimental data for disproving a long-standing conventional explanation for the differential shrinking and swelling of wood, which is based on analogy, is going halfway only in righting the error. Scientific etiquette requires, if possible, the submission of an acceptable fundamental explanation.

It appears that the microstructure of the ray cells in conjunction with that of the radial wall of the fibers differs from the microstructure of the tangential walls of the fibers sufficiently to warrant a satisfactory explanation on that basis.

Mention has been made previously that ray cells which had been measured swelled longitudinally 3 to 4%. They swelled less than the tangential walls of fibers because of being abundantly pitted, which produces random crystallite arrangement about the pits. This in turn reduces maximum swelling in the general longitudinal ray-cell direction or radial direction of the tree. On the other hand, ray cells manifest maximum tangential swelling and in addition, the tangential walls of tracheids are pitless and consequently they also manifest maximum tangential swelling.

The radial walls of the tracheids are perforated copiously with pits about which the crystallite arrangement is ringlike which reduces maximum radial swelling but which manifests maximum swelling tangentially. Thus the ray cells and the radial walls of the tracheids manifest reduced radial but maximum tangential swelling. Accordingly, the radial swelling of wood is less than the tangential because of the proportion of randomly arranged crystallite microstructure in the ray cells and the radial walls of the fibers which reduces maximum radial swelling, whereas all the wood substance in ray cells, radial fiber walls, and tangential fiber walls manifests maximum tangential swelling.

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DISCUSSION

G. J. Ritter: The first point is the relation of structure to pulping processes. In what way is the structure of wood of value in developing a process of making pulp? Does the porous nature of the wood, the pits, etc., the different arrangement of fibers, have anything to do with pulping wood—e.g., in the penetration of the liquor into the wood?

Sidney L. Schwartz: Before the fibers can be released the pulping liquor must enter the cell wall to attack the cementing material. With a block of wood it would be difficult to get liquor into the cell walls; consequently, the wood is chipped to a size which is readily penetrated by the liquor.

Merle A. Heath: You spoke of the difference in swelling of softwoods in different directions. How do the hardwoods behave? Do you get the same difference in the tangential direction and the radial direction?

Dr. Ritter: That is general. The radial direction is less than the tangential.

Dr. Heath: Do you think the pit structure explains it in both cases?

Dr. Ritter: That does enter into the matter, all right, except that pits do not appear as plentiful in hardwoods nor are they as large as the pits in softwoods, but the ray cells are full of pits, in the same way. The swelling of the radial wall of the fiber does not necessarily have to be exactly the same as the swelling of the radial wall of the ray cells. Perhaps no two fibers swell exactly the same in the tangential direction. This has been done: take a very thin section of wood in which you have ray cells on one side and no ray cells on the other. There you would have the radial wall of the fiber on one side and the radial wall of the ray cell on the other side. They contact one another at the interface. Mr. Thiemann (who used to be at the Forest Products Laboratory) prepared some such sections, oven dried them, and then water soaked them; he found that they did not swell exactly the same on the two sides. He found some instances where the radial wall of the fibers swelled a little more than the ray cell side. There was a little coping toward the ray cell side of the section. Mr. Thiemann drew a circle, using the arc of the curved specimen, and found the ray cell side was $^{3}/_{100}$% less than the fiber side.

Dr. Kerr: In coniferous wood, what is the differential swelling in percentage?

Dr. Ritter: In the radial direction, we will say it is 3.5 to 4% and in the tangential direction, 7 to 8%.

It is about twice as great in the tangential as in the radial.

Dr. Kerr: Do the hardwoods show less differential swelling than the conifers?

Dr. Ritter: I cannot tell that exactly.

L. V. Forman: One comment about this first question might stimulate discussion or at least thinking. The question has been asked: "What influence does wood structure have on pulping processes?" I think an analysis of the problem shows that it has a tremendous influence. To stimulate some thought along that line I would suggest the concept that all the chemical processes of pulping are really semichemical processes because we break the wood down into chips first and then apply the chemical. The manner in which we do this affects the results. The manner in which we do the chipping, whether with sharp or dull knives, etc., has some influence on at least some of the processes. Incidentally, one of the big features of the influence of the structure of wood pulping processes probably has to do with the question of penetration. This is assuming more and more importance because we are seeking higher speeds in our processes. We want to do the job at higher temperatures, higher pressures, and by means of a more complex operation. Some of the limiting factors are definitely found in the wood structure that we are trying to cook. But, if we carry out the penetration phase properly and cook according to some of the new semichemical processes, the fact remains that we are fighting the effect of the original structure. We have to defiber the chips and destroy the original structure before we produce something from which we can make a sheet of paper. Therefore, I think an analysis of the problem shows there are many ways in which the original structure affects the pulping processes.

Dr. Ritter: Suppose you have dense wood. You might take maple and aspen. Does the difference in porosity help in any way in impregnating the chip with the pulping liquor?

Dr. Forman: I am not prepared to answer that question by means of specific data but I think it is safe to say that is true.

Dr. Ritter: Is there anyone who has some data on that?

D. O. Adams: In the pulping of oakwood, for example, which Dr. Ritter spoke of as being a very dense wood, the wood appears to cook rather easily. Oak is a ring-porous wood with large vessel segments concentrated at the springwood portion of the annual ring; I wonder if those vessel segments do not act as feeders for getting the liquor into the wood in the first place. The spaces between those very highly porous areas may be quite dense. Oak seems to pulp fully as easily as some other woods, poplar for example, and yet poplar is a fairly open structure material, whereas at least portions of the oak are very dense.

Dr. Forman: Wood density, as normally expressed, is not necessarily a good criterion of the rate of penetration which depends frequently on the actual detailed structure of the wood; the latter is probably more important in terms of processes than is the treatment of the over-all density.

W. A. Sisson: You show that cells tend to separate more easily in the radial direction. Is that taken advantage of in making chips, so that they will separate more easily?

H. W. Rowe: Normal chipping appears to be a combination of tangential and cross-section cutting; if this is so, is there any better way of preparing the wood for pulping? I understand that one pulp mill has studied the effect of crushing chips on its properties after pulping; in sulphite cooking they found a considerable degradation in the pulp strength but not in the kraft process. Can that be explained by the morphological structure of the wood?

A. T. Walton: On the West Coast they found that extremely large chippers tend to crush and will decrease the strength of the paper to some extent. We do a considerable amount of chemical pulping in our refiners. I would like to know the difference in the microstructure of the wood as it increases in age, particularly the difference between young second-growth material and the 600-year-old material which we find in the Douglas fir region, and what effect such differences might have upon the properties of the pulp produced by purely chemical means from the wood.

Dr. Ritter: You will have more extractives in the old heartwoods.

Dr. Kerr: The structure of the wood fibers change since the cambium cells which give rise to the fibers increase in size as the tree becomes older, and the cambial cells enlarge both in length and in diameter. There is a marked change for approximately 60 years, and a slower change indefinitely. In a thousand-year-old sequoia, there are tracheids approximately 10 ml. long.

Harold Tarkow: Dr. Ritter, as to the adhesion between cells in delignified wood, what evidence is there that the bond is chemical and not mechanical?

Dr. Ritter: Some available evidence indicates that the bond is chemical. For example, in holocellulose (which is carbohydrate in composition), the lignified cells adhere tenaciously. They can be separated with dilute alkali which dissolves the hemicelluloses.

Mr. Tarkow: I believe it is Harlow who contends that proof is still lacking that there is intercellular bonding material other than lignin.

Mr. Walton: There is evidence upon which this is based: wood is more easily disintegrated at elevated temperatures in the presence of water; this would indicate that a part of the bond holding the fibers together is mechanical in nature, and that such a bond tends to soften at the higher temperature.

Dr. Ritter: Let us now consider the purification of pulps for high-grade paper. What is there about the fibrous structure that is related to the purification process? By purification I understand you mean treating it in some chemical way.

M. N. Fineman: In your talk you mentioned that it was possible to treat the fibers in a very mild manner and dissect them chemically but that, in some other procedures, the method used actually destroyed a good deal of the alpha-cellulose. Suppose you wanted to remove the hemicelluloses: would the procedure be too severe and cause too much damage to the alpha-cellulose; what procedure would you recommend?

Dr. Ritter: In the first part of your question you mentioned the removal of some of the hemicelluloses.

In the first place, you want to remove all of them. If you do that, you will have an alpha-cellulose which will be close to 50% of the wood. If the refining procedure is done carefully and you are sure that you have a solvent that will only remove the hemicelluloses, you can obtain a high yield. We can obtain a 50% alpha yield, but whether that alpha would contain impurities that might interfere with the preparation of cellulose acetate, cellulose nitrate, or ethylcellulose is another question. The alpha that is used for making a viscose pulp does not have to be as carefully prepared as one for making cellulose acetate. In making cellulose acetate from wood pulp, extreme care must be taken. In most cases, trouble will be experienced in obtaining a haze-free dispersed cellulose acetate. One way to find out whether the dispersion is clear is to acetylate in a medium that will dissolve the cellulose acetate. You can find out the nature of the haze by following the acetylation under the microscope. Sometimes you find a small residue of the fiber. The more of these residues present, the hazier the solution will be. What trouble do they cause? Well, you cannot get a clear film for one thing. It is troublesome material to filter.

Dr. Kerr: You mean it is due to the extractive?

Dr. Ritter: No, you will have small bits of undissolved fiber left.

A. P. Yundt: Concerning the haze, I have made both the nitrate and acetate of xylan. I was unable to dissolve them in any of the available solvents. They would swell in some solvents, but they would not dissolve.

Coming back to the alpha pulps, I think that something that is very often overlooked should be emphasized here. When the enzymes lay down the fiber structure, they are not absolutely specific in respect to the position within the fiber. As a result, there is some cellulose laid down within the basic structure that includes most of the hemicelluloses and perhaps even some in the lignin. The net result is a semipermeable membrane, similar to that used in osmotic pressure equipment. Since the hemicelluloses, to some extent, are laid down inside this semipermeable membrane formed by the insoluble cellulose, they will be difficult to remove. It is necessary to swell the cellulose membrane structure by high concentrations of alkali and to allow long diffusion times if a high percentage of the hemicelluloses is to be dissolved out. The same is true in delignification problems. It is necessary to degrade the lignin and get small lignin molecules in order to completely remove the lignin if we consider that the hemicelluloses and the cellulose are to be untouched, because they form a membrane through which this lignin must be diffused.

Dr. Ritter: You made some good statements. Even though you dissolve certain constituents, we have to remove them, and most of us are in too much of a hurry in the purification of our product. I have heard the boys say: "I washed it six times and it is not acid or alkaline." That does not mean anything. It takes a lot of soaking, steeping, and washing to diffuse the dissolved material through the cell wall to the outside where it can be washed away. The bottleneck is to diffuse the material out of the cell wall where a large amount of water can carry it away.

H. Mark: In connection with wood structure and highly refined pulps, I would like to ask about these skins. In connection with the haze of cellulose acetate and cellulose nitrate and with filtration difficulties of other cellulose solutions, what are these materials chemically? Has one ever had enough material of these wrappers to determine whether they are cellulose or some other carbohydrate? Do we know anything about that?

Dr. Ritter: To my knowledge that information does not exist. There might be unpublished data. That is the reason we have an open discussion of this kind. When one prepares a review, he can use only published data.

H. F. Lewis: An article published ten years ago by Brauns and Lewis dealt with the composition of the residue remaining after the treatment of pulp fibers with cuprammonium solution. In this study we treated several pulps with cuprammonium solution and separated the insoluble residues, following this separation with washing, retreatment with a swelling agent, and washing until we were sure no further solution of cellulose was taking place. Two particular pulps were of interest—the first, a conventional western hemlock bleached sulphite pulp, the other a highly purified alpha-cellulose sent to us by the Cellulose Research Corporation. From these we obtained two entirely different results.

The first pulp was a western hemlock sulphite from which the medullary rays and other short-fibered material had been removed by fractionation. It contained 85.3% alpha-cellulose, 98.2% Cross and Bevan cellulose, 3.8% pentosans, and 1.9% lignin; the copper number was 2.05 and the viscosity 40 by the TAPPI method. This pulp was treated in accordance with the directions in the article and yielded approximately 1.4% of residue on the basis of the ovendry pulp. When slightly moist, the residue was grayish blue, which changed to a light blue on drying overnight. The preparations contained copper and, on analysis, was shown to contain about 30% (as copper oxide). The copper appeared to be present in some form of chemical combination. The copper-containing residue was washed with ammonium hydroxide and water and acidified with acetic acid or dilute hydrochloric acid, which hydrolyzed it, giving a grayish precipitate and a greenish-blue solution. The precipitate was removed by centrifuging and the clear solution dialyzed against distilled water. As dialysis proceeded, the solution set to a solid gel which, on standing, lost water. After copper was no longer detected in the outside water and the contents of the dialyzing bag were neutral, the gelatinous material was precipitated by pouring into absolute alcohol. The product separated as a white powder which was washed with an organic solvent and dried in a desiccator over sulphuric acid and sodium hydroxide. The material thus obtained still contained about 0.46% ash because of some copper adsorbed by the gel. The analysis of the preparations thus obtained gave a mean value for carbon of 44.2% and for hydrogen of 6.25%. The respective figures for cellulose are: carbon, 44.44% and hydrogen, 6.17%. Tests for uronic acid and methoxyl were negative. The white powder was difficultly soluble in water and insoluble in alcohol, pyridine, and acetic acid. On

hydrolysis with fuming hydrochloric acid, the product dissolved to give a clear solution colored a faint blue by the trace of copper. This was removed as a sulphide, and the colorless solution was found to reduce Fehling solution strongly. A quantitative estimation of the reducing sugars in this solution indicates a yield of 97% (calculated as glucose and based on the weight of the original solid). The qualitative micro test for mannose and the fermentation test for galactose on the hydrolysate indicated the presence of these sugars. Less than half of the material was fermentable. The actual calculation pointed to the presence of 45% fermentable sugars. The micro-pentosan determination by the dinitrophenylhydrazine method revealed the absence of pentosans. The original blue copper compound changed its characteristics on drying, and it was not decomposed by dilute acid to form the solution from which the gel separated. A gray gelatinous precipitate was obtained rather which, on drying, yielded a horny product containing 45.16% carbon and 6.3% hydrogen. This product contained about 1% methoxyl. On hydrolysis with strong hydrochloric acid, a ligninlike precipitate was obtained and a filtrate which strongly reduced Fehling solution.

The second pulp was a highly purified spruce wood pulp containing 99.1% alpha-cellulose, 0.7% pentosans, 0.077% ash, and had a copper number of 0.049 and a viscosity of 32 centipoises. The pulp, when beaten in a Valley beater, neither lost freeness nor did the stock hydrate. The handsheets were weak and belied the high viscosity of the pulp. This pulp was treated with cuprammonium solution, and the various concentric cylinders of cellulose in the fiber with secondary walls separated easily from each other as though the material separating these layers had been removed in the process of purifying the pulp. An extremely small amount of insoluble material was obtained, which indicated that the substance giving this blue copper-containing precipitate had been largely removed from the pulp. The first pulp, on the other hand, which gave this residue gave a sheet of high strength. I cannot say for sure that this is the insoluble material giving the haze following the acetylation of cellulose which Dr. Mark speaks about, but it may be.

Dr. Tarkow: I do not recall the paper referred to by Dr. Lewis, but I should like to call attention to the work reported by Milton Harris. Harris found that the primary wall of the cotton fiber contains about 1% of pectic material whose presence interferes with the normal acetylation of the primary wall. Haze is very common with such acetylated material. The removal of this pectic material permits the entire fiber to be acetylated uniformly to a product having good dissolving properties. Perhaps the same interfering material is present in wood pulps.

Dr. Ritter: Dr. Ludtke did some work on the composition of what he called skin substance. He oxidized this skin substance under conditions in which carboxyl groups were formed. When the carboxyl groups were determined and calculated on the basis of a carbohydrate which he assumed to have a molecular weight of about 200, the content of skin substance amounted to about 2%. That is approximately the amount of uronic acids in cellulose fibers. It would be quite comparable with the polyuronides, but the trouble with those oxidized materials and polyuronides is that I cannot see how they would survive through the treatment of making a purified pulp.

Dr. Kerr: It is difficult to believe in the existence of a skin substance such as Ludtke has postulated. According to Ludtke's work, the wall is built of small particles of cellulose, each surrounded by skin substance. This would mean that the cellulose is a discontinuous phase and the skin substance a continuous one—essentially a "brick-and-mortar" concept. Considering all the work that has been done on the structure and properties of natural and synthetic fibers, Ludtke's hypothesis is nothing short of fantastic.

Fred Olson: I do not know whether the skin is responsible for the haze in cellulose or not but the skin can be made by drying a good acetylated pulp and allowing it to stand. We dry it for as long as 8 years; since the pulp will age even on laboratory storage, the amount of skin material, if it is skin material, increases, because the haze and dopes become worse as the cellulose ages in the bottle.

Dr. Ritter: If you pulp a green wood and keep it wet after it is pulped and purified, the material is apt to acetylate more readily than one that has been dried; is that right?

Mr. Olson: Yes.

Dr. Ritter: I want to mention something theoretical on my part. Maybe it is partly visionary but I want to get your reaction. That is: why are all of the crystallites arranged in a vertical direction in the trees? That means they are crosswise in the ray cells and lengthwise in the fibers. If the liquid moves in a vertical direction in the fiber, I am wondering whether that would not start a vertical movement of the protoplasms in the ray cells also, because they are connected with the fibers through pits. If we could visualize it in that way, then we could account for the crystallites being arranged vertically in both the ray cells and the fibers around the pits.

Dr. Kerr: It seems to me that this is doubtful.

Dr. Ritter: You don't think this stream in the fibers, which is in communication with that in the ray cells, would tend to set up a current in the vertical direction?

Dr. Kerr: The idea that the orientation of the fibrillar structure is determined by the direction of the streaming protoplasm is an old concept in botanical literature. I doubt the validity of this concept. In many woods all the elements are not oriented parallel to the vertical direction of the tree. In certain hardwoods, one finds that the orientation of the cellulose in the large porous vessels is approximately at right angles to the vertical direction of the tree. The problem of what determines cellulose orientation in the cell is a difficult one. We have done a lot of work on it and we still do not know the answer.

Dr. Ritter: Does cotton have this type structure?

Dr. Kerr: No. In cotton the cellulose of the secondary wall is oriented in a spiral. The direction of the spiral reverses many times along the length of the fiber. This reversal of spirality of the cellulose chains along the length of the cell is unique in cotton.

New Fly Ash and Boiler Slag Uses

L. JOHN MINNICK

A brief description of the early work on fly ash utilization is given. The chief use has been in the field of concrete and Portland cement products. Some successful applications as an asphalt filler have also been reported.

Recent research developments are presented with particular emphasis being placed on the utilization of fly ash and boiler slag in producing ceramic bricks. Recent work in the concrete and asphalt fields is also discussed and brief mention is given of other types of investigations which are under way.

DURING recent years there has been a considerable increase in the amount of fly ash and boiler slag produced in this country. The installation of many new power units as well as the general widespread use of pulverized coal as a fuel is responsible for this upward trend. The disposal of these materials is becoming increasingly more difficult due to limited available space resulting in many instances in serious economic problems. There is a good deal of interest, therefore, in the possibility of finding new commercial outlets for these materials.

The purpose of this paper is to outline some of the interesting possibilities for the use of fly ash and boiler slag and to discuss briefly two of these developments, namely, the use of fly ash and boiler slag in ceramic products and the extended use of these materials in Portland cement compositions. These two fields offer two immediate outlets where very large tonnages of the materials may be used.

As a result of numerous activities over the past 25 years there is today a substantial amount of fly ash being used for commercial purposes. For example, it is being used in ready mixed concrete, concrete pipe, Portland cement grouting mixtures, and in bituminous compositions. The continued use of fly ash is definitely assured, although the amount of material that is being consumed at the present time is a relatively small portion of the total amount being produced.

Until very recent years, there has been relatively little activity in connection with the utilization of boiler slag. Since this material is also produced in large amounts, it is of nearly equal importance to fly ash and also represents a difficult disposal problem. It is evident that the producers of fly ash and boiler slag must continue to apply considerable effort to the research studies on utilization of these byproduct materials. Many new fields must be explored and some of the discarded possibilities must be re-examined and studied to determine what might be done to overcome the objections and difficulties that were previously encountered.

In order to expedite the commercial use of these products, the Philadelphia Electric Company and G. & W. H. Corson, Inc., at Plymouth Meeting, Pa., several years ago entered into a joint research and development program. More recently the Consolidated Gas Electric Light and Power Company of Baltimore, Md., and the Public Service Electric & Gas Company of Newark, N. J., have joined in this research program, and several other large fly ash producers have also indicated their desire to do likewise. As a result of this concerted effort to find other uses for fly ash and boiler slag, a number of very promising outlets have been developed. The information given in this paper refers to some of the activities of this group over the last few years.

L. JOHN MINNICK, Chemist, G. & W. H. Corson, Inc., Plymouth Meeting, Pa.

CHARACTERISTICS OF FLY ASH AND BOILER SLAG

A bibliography is given at the end of this paper covering most of the published information on fly ash. Included in this bibliography are several references to uses of fly ash other than concrete, for example the paper by Weinheimer covers a number of interesting applications for fly ash and also touches on some of the problems involved in the handling of this material.

A few of these early investigators pointed out the differences in characteristics of various types of fly ash. For example, Davis in his work studied the effect of the carbon content on the performance of fly ash in concrete. Weinheimer described some of the characteristics of fly ash and described the small spherelike phase that is usually present.

A number of studies in the Corson laboratory have shown that fly ash has widely different properties depending on the source of the material. Samples of fly ash from all parts of the world have been examined and it is evident that in addition to chemical composition (Table I) the physical properties of this material are quite varied. In fact, there are materials which are referred to as "fly ash," obtained from coal burning operations which differ quite markedly from the products produced by the combustion of powdered fuel. The materials referred to in this paper are formed in powdered fuel burning operations only and

Table I. Analysis of Fly Ash

	Philadelphia	*Newark*	*Chester*
SiO_2	40.32%	45.42%	34.98%
Fe_2O_3	13.39	11.54	13.79
FeO	3.95	3.74	4.96
Al_2O_3	32.92	29.62	27.05
CaO	2.34	1.93	2.85
MgO	0.74	0.94	0.82
Carbon	5.79	4.81	14.84
Specific gravity	2.46	2.53	2.41

Sieve Analysis

	Philadelphia	*Newark*	*Chester*
On 60-mesh	2.0%	1.5%	1.0%
Through 60 on 100	8.0	3.0	5.0
Through 100 on 200	11.0	11.0	25.0
Through 200	79.0	84.5	69.0

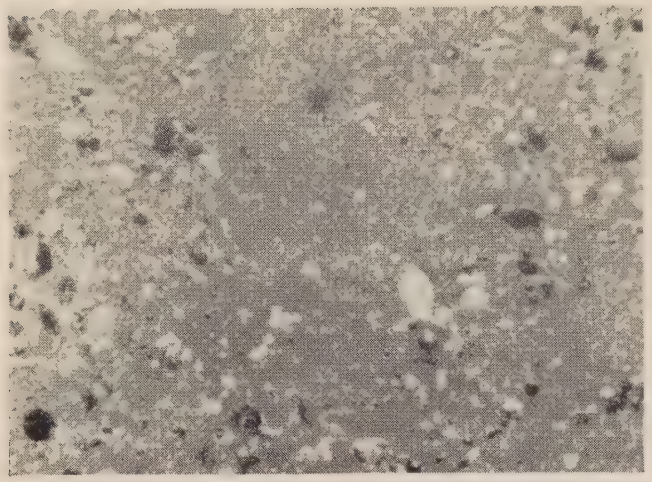


Fig. 1. Philadelphia, Pennsylvania, fly ash—×50

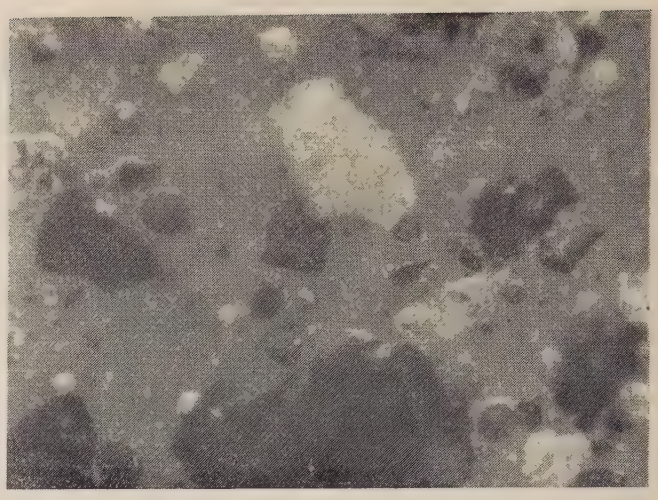


Fig. 3. Paris, France, fly ash—×50

are collected by carefully controlled systems such as the Cottrell precipitator, American Blower Company dust collectors, and the like. Figures 1, 2, and 3 show photomicrographs of different samples of fly ash.

The Philadelphia material (Fig. 1) is a very useful product which performs well in Portland cement and other compositions and is perhaps typical of much of the material available in this country. It is composed of three different phases. The first, a white-ash-like phase consists of very finely divided particles, being of the order of a few microns in diameter. The second phase is a red material which is evidently high in iron and also consists of very finely divided particles. The third phase is black and represents the material that contains residual carbon either as a complete carbon particle or as a small particle of ash which is coated with a carbon layer. The average particle size of this material is somewhat larger than that of the other two phases. These three phases are usually found in about equal amounts in many of the fly ash materials studied.

The samples of Chester and Paris materials (Figs. 2 and 3) show considerable difference from that of the Philadelphia product, reflecting a difference both in the method of burning and the method of collection. These materials are high in carbon content and, as is usually found for fly ash containing appreciable amounts of carbon, are somewhat coarser in average particle size. Most of the carbon is found in the large size fraction of these products. Thus by screening Chester fly ash on a 200-mesh sieve the major portion of the carbon can be removed.

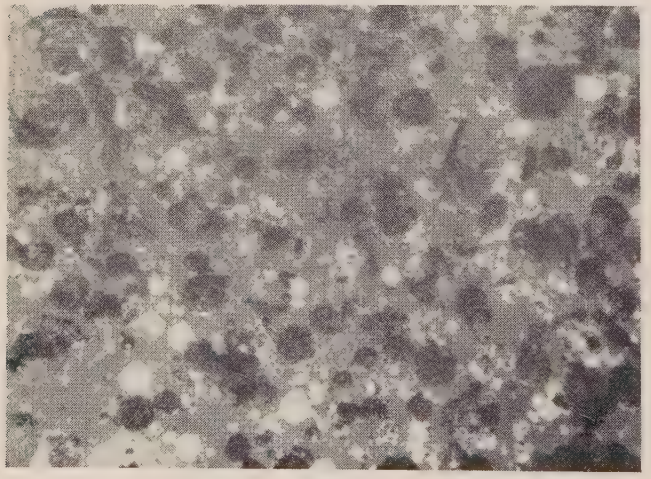


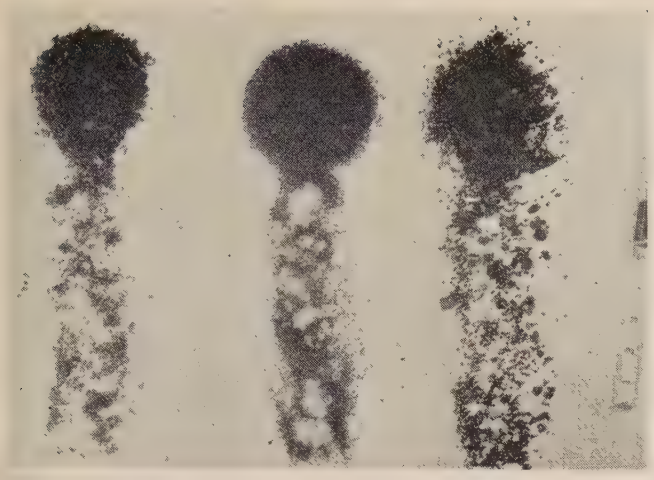
Fig. 2. Chester, Pennsylvania, fly ash—×50

Interspersed in the fly ash samples are small hollow spheres which have been reported frequently by other investigators. The amount of spheres found is extremely variable. In some materials (for example, Chicago material), the amount of spheres is very much greater than that found in other products (New York and Philadelphia materials).

In addition to the physical characteristics of fly ash, there are several important chemical properties that should be noted. First, and of considerable importance, is the pozzuolanic activity of fly ash when combined with Portland cement. There is some evidence that high carbon content material does not possess as high a pozzuolanic reactivity as that found in low carbon content materials. Secondly, fly ash possesses varying amounts of soluble salts such as sulphates, alkalies, and the like. These salts in certain cases act chemically on other components of the compositions in which the fly ash is being used and in some instances serve as a source of efflorescence in concrete and structural masonry units. Another characteristic of fly ash is its somewhat variable pH. Some of the material is found to be acidic and other material is found to be basic. This property is important for many filler applications where pH control is required.

A further important characteristic of fly ash is the glasseous nature of its composition. Studies in the petrographic microscope and x-ray diffraction equipment clearly show that nearly all of the fly ash is present as a high melting glass highly stained with iron. The iron content is present both as ferrous and ferric iron, the ferrous iron acting as a strong flux in the glass formation. The softening temperature of fly ash varies depending upon the sample examined but is usually in the neighborhood of cone 5 to cone 10 (2156 to 2300°F.). This softening temperature has an important bearing on the utilization of this material in the ceramic field.

Figure 4 represents three different samples of boiler slag obtained from three of the Philadelphia Electric Company stations. It is clear from this photograph



Chester Richmond Schuylkill

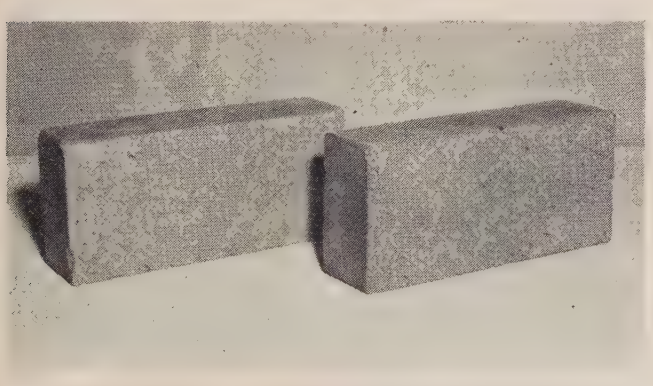
Fig. 4

that there is a wide difference in slag materials, perhaps even more than is found in fly ash products. Since the boiler slag is utilized in many of the same applications as fly ash, it is evident that complete knowledge of this material is also essential in the development of satisfactory performance of this product. The samples shown in the photograph are all wet bottom slag and represent the kind of material that is obtained from this method of disposal. Dry bottom boiler slags are also available in increasing quantities. The density of these materials varies between about 75 and 120 pounds per cubic foot. The density is particularly important since many applications for aggregate materials of this type require low weight in the product.

Chemically the boiler slag is about the same as fly ash with the exception that the carbon content is usually zero. Some variation in iron content has been noted, but this has not been very great. Boiler slag from a wet bottom operation is basically a crushed, high-melting black glass.

RESEARCH DEVELOPMENTS IN THE CERAMIC FIELD

There has been some effort during the past ten years to utilize fly ash in the brick industry although the few attempts which were made either failed or were abandoned. Weinheimer, who attempted to use fly ash in brick, drain tile, hollow tile, and flower pots, reported unsatisfactory results and concluded that fly ash could not compete with low cost clays and that it did not have the proper properties to improve the quality of the product. Thorson and Nelles concluded that using as little as 4% fly ash in a brick caused poor results, i.e., cracking and a weak and brittle structure. As a result of these findings, these investigators abandoned the project.



Left, shale brick; right, fly ash-slag brick.

Fig. 5

Most of the above-mentioned efforts were directed to the use of fly ash with clay in existing brick plants. The research at the Corson laboratory has been directed both to this type of utilization and to the formation of a ceramic product made entirely of fly ash and boiler slag. Since these two developments offer different problems, they are presented here separately.

Fly Ash–Slag Brick

Figure 5 shows a brick made from fly ash and slag compared with a standard shale brick, both of which were made in a standard brick-making machine and processed in exactly the same way. The fly ash–slag brick is outstanding for many reasons, but perhaps the most important point to observe is that it so completely resembles the shale brick in appearance that it is difficult to distinguish one from the other. It is completely possible by the proper burning of a body made of fly ash and boiler slag to develop a high-grade red vitrified product.

As a result of the development of this brick, the Corson laboratory has carried on an intensive research program over the last two years and has also established a research fellowship at the School of Ceramics of Rutgers University. The following list indicates the scope and extent of the studies which have been made:

Body composition
Preparation of slag
Study of methods of production of proper grain size
Development of plasticity and moldability
Studies of dry press characteristics
Studies of vacuum de-airing and extrusion characteristics
Studies of the effect of green strength increasing binders
Studies of drying rates
Stacking of green ware
Vitrification studies
Bloating studies
Oxidation studies
Abrasion studies
X ray studies
Petrographic studies
Materials handling
Methods of chemical and physical control
The effect of variation in raw material and processing on performance

Most of these investigations have been completed and considerable information is available for a number of types of fly ashes and boiler slags. The range of composition that will produce a good brick extends from 80% fly ash and 20% slag to 40% fly ash and 60% slag. The development of plasticity and moldability directly depends upon the method of preparing the grain size of the slag which should be kept low in fines, and the bulk of the material should be between a 10- and 20-mesh sieve. This requirement has made it necessary to employ special grain size preparation methods.

The carbon content of the fly ash is important and affects the porosity of the body and also affects the firing cycle. The percentage of fired absorption increases

directly with an increase in carbon content. In addition, the problem of complete oxidation of high carbon ashes is quite critical and the firing cycle must be controlled carefully to prevent bloating of the fired brick. In order to facilitate the manufacture of this brick a small amount (approximately 1 to 2%) of a green-strength increasing agent is used to assure ease in handling while in the wet condition.

The brick has certain features which make it desirable over conventional type materials. First, due to the absence of any water of hydration in the body, it has been found that a very rapid drying and firing cycle may be employed. In the case of a high carbon fly ash, this feature is offset somewhat since an extended oxidation time is required, but in all cases an extremely fast drying time is feasible. The over-all volumetric shrinkage of the brick is very low, both during the firing and burning cycles, running usually around 1 to 2%. Figure 6 illustrates the difference in shrinkage between the fly ash–slag brick and a standard shale brick made in the same kiln. This feature is highly beneficial since it affords high precision in dimension which means that all of the brick in the kiln hold closer to the same size, preventing shrinkage, cracking, warpage, and distortion such as is frequently associated with high shrinking clays. The firing range for the material is very broad, much broader than is customarily found in clay materials usually running between 1750 and 1950°F. There is very little difference in appearance between the products made at the different temperatures, but the brick made at the higher temperature shows improved strength due to more complete vitrification.

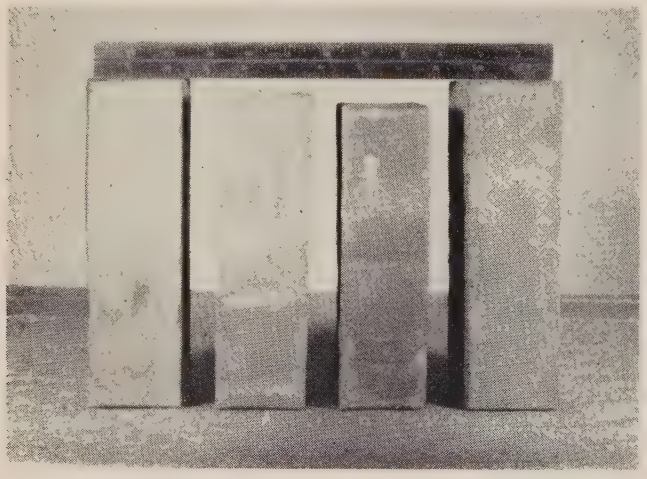


Fig. 6. Three bricks on left are shale brick taken from different points in kiln brick on right is fly ash clay brick—size is constant over entire kiln

Fundamentally the formation of this product represents the merging of individual grains of fly ash which are heated to a point where each glasseous envelope gradually softens. The softened glass layer blends in with the slag and other fly ash particles and on cooling forms a unified vitreous structure. The slag is very firmly held due to this softening action and there is a definite bond at the interface of the slag and fly ash matrix. Since the slag is very much larger in particle size than fly ash, it does not oxidize readily and therefore retains its original black color. The fly ash, however, is converted to an attractive red coloration. The slag at the outer surface of the brick is oxidized sufficiently that the outward appearance of the brick is a uniform red color although in breaking it open the slag may be observed as a black groglike component. The color of the product may be varied from a light reddish buff to a dark reddish purple. This is accomplished both by proper blending of the ingredients and also by subjecting the material to the right atmosphere in the kiln.

In addition to the laboratory tests a varied number of field tests have been conducted to demonstrate the practicability of using this body in conventional brick machinery. Tests have been run at brick plants using down-draft periodic kilns, beehive kilns, circular kilns, and several with tunnel kilns. Brick have also been made in a flower pot kiln at 2750°F. in 35 hours, and in a tile kiln at 2200°F. in a 48-hour firing cycle. In all of these tests satisfactory brick were produced with no apparent problems in the manufacturing process. Table II gives the average properties of brick produced from fly ash and slag and includes a typical set of tests for a shale brick.

In addition to the above tests, the brick have been examined in a practical way and found to be very similar to other face brick. A wheelbarrow load may be dumped without breakage, individual bricks can be broken with a trowel by bricklayers, mortar can be applied in the usual way, and the material, from a mason's point of view, seems identical to a first-class shale brick.

Table II. Properties of Fly Ash–Slag Brick Fired to 1900°F. Compared with Standard Shale Brick

	Fly Ash–Slag Brick	*Shale Brick*
Compressive strength (p.s.i.)	6000–8000	4000–8000
Modulus of rupture (p.s.i.)	1600–1800	500–2000
Absorption	8–10%	8–12%
Saturation coefficient	0.78	0.78–0.90
Color	Light to dark red	
Efflorescence (McBurney)	None	
Freezing and thawing (A.S.T.M.)	No breakage or loss in weight after 50 cycles	
Weatherometer (equivalent to 7 years' exposure)	No breakage or loss in weight	

Various esthetic effects are possible with this product and it has been found that by proper temperature control, a stippled effect may be produced on the surface during the firing cycle which lends itself ideally to the art value of the product, and helps put it in the class of expensive face brick.

On the basis of the above tests an economic study has been made of the possibility of constructing new plants for the manufacture of brick at several specific sites. This has required the designing and engineering of several types of brick manufacturing units. Studies are nearly completed, and on the basis of the findings it is apparent that the construction of brick plants near or adjacent to power plants is economically feasible and that a very large consumption of fly ash could be realized as a result of these plants. It is expected that in the very near future sufficient information will be available to actively consider construction of plants of this type.

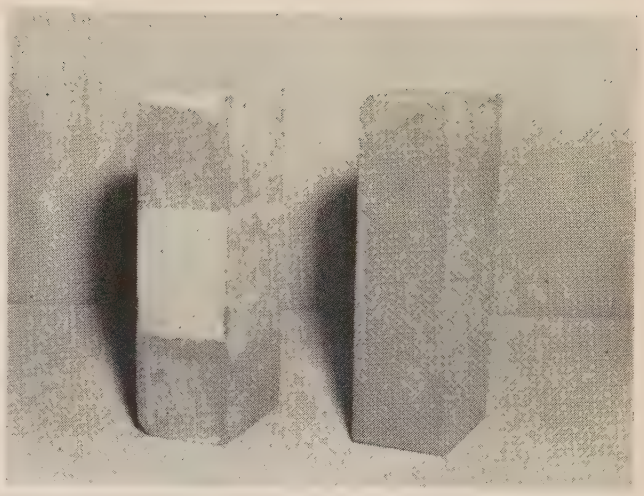
In addition to the manufacture of brick, experiments have been run on producing other ceramic materials, for example sewer pipe, drain tile, and flower pots and it has been demonstrated that the same type of body which will work for brick products will do an outstanding job in these other fields. It has been found, however, that the ordinary type of salt glazing does not perform on fly ash–slag compositions although other types of glazes work quite well.

Fly Ash–Clay Brick

As mentioned previously, some efforts have been made to introduce fly ash into clay brick manufacture. In addition to the difficulties already mentioned, the formation of a scum on the brick product has offered a serious objection to the development of this use. A number of field tests have been run where fly ash has been used to replace 25 to 50% of the clay and usually the fired product shows a bad scum, chiefly derived, it is believed, from the drier operation. Many of the brick that have been made show superior properties of a straight clay brick as far as strength and structure of the brick is concerned, although it is obvious that if the appearance is marred by an unsightly scum, the brick has no commercial value. The School of Ceramics, at Rutgers University, has studied this problem at great length and as a result of their investigation a new de-scumming agent has been perfected which does an outstanding job of eliminating this problem when used in a fly ash–clay brick. While the study of this material has not proceeded to a point where a detailed description of it can be made, it is of interest to point out that about a quarter of a million brick have been made in various plants in the Philadelphia area to test out this development. These bricks were made in surface clay plants (with the exception of one case where a shale product is normally produced). All of these plants have a scum problem to begin with and tests with fly ash have shown aggravated scum conditions. The results with the de-scumming agent have eliminated the scum situation practically completely (Fig. 7). The product produced in these tests is very satisfactory in color, general appearance, durability, and strength. Fly ash has been used in amounts up to 70% by weight of the finished product.

The surface clay plants in which these tests were run employ standard extrusion machinery but do not utilize de-airing. As a result the normal product usually shows the existence of structural laminations. Those products in which fly ash was used did not show these laminations. Figure 8 illustrates this effect. The general strength of the brick is improved, therefore, by the use of fly ash as is the resistance to freezing and thawing. One further advantage found for fly ash is the control of shrinkage made possible by varying the fly ash content. Most surface clays show a marked shrinkage during drying and firing and this can be reduced.

While there are many brick plants that have plenty of clay and that produce a high-grade product, there are also a large number of plants that are running out of clay or have difficulty in operating during some seasons of the year, or have manufacturing problems



Left, without descumming agent; right, with descumming agent.

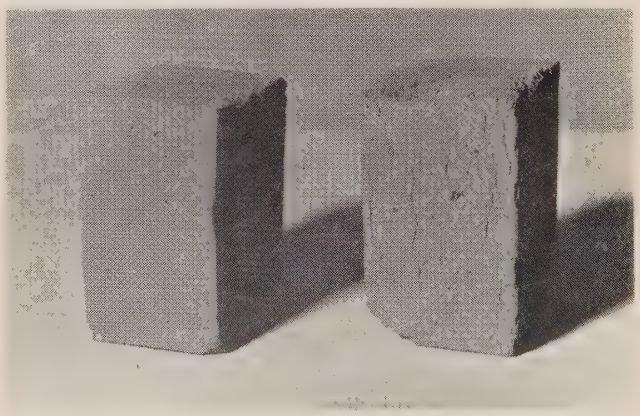
Fig. 7. Fly ash-surface clay brick

because of inferior clay. These latter plants all offer splendid opportunities for potential consumption of fly ash. At least two plants near Philadelphia are planning to use this material in the near future.

USE OF FLY ASH AND BOILER SLAG IN PORTLAND CEMENT COMPOSITIONS

Fly Ash

The use of fly ash in concrete continues to receive a great deal of attention in this country. Fly ash is a pozzuolanic material and like other pozzuolans develops considerable strength when used in conjunction with Portland cement although the strength is developed rather slowly. Most of the early reports on the use of fly ash in concrete show the effect of the fly ash addition only after some time has elapsed, for example, six months or a year. Early strengths, for periods up to about 28 days, are somewhat lower for concrete where fly ash has been used to replace Portland cement. As a result of a number of recent studies, it is now evident that when fly ash is used in larger amounts the early strength is equal to that of ordinary concrete and the long-term strength is considerably higher. This applies to periods of time as short as 24 hours. The basis for these results depends on the utilization of fly ash as a fine filler as well as a pozzuolanic additive. The amount of fly ash required to get early strength is roughly in the



Sawed section, fly ash-surface clay Sawed section, straight clay

Fig. 8

neighborhood of 25% of the weight of the sand content.

Tests with mortar mixtures show that the maximum strength is obtained when the Portland cement and fly ash content correspond to the voids existing in the sand. Some work has also been started with concrete and similar results are indicated. Thus where a bag of cement is used with 2 volumes of sand and with 3 or 4 volumes of coarse aggregate approximately 40 pounds of fly ash are calculated to be needed to fill up the voids not occupied by the Portland cement. When this amount of fly ash is used, a lower water requirement is necessary for each unit volume of concrete and after 7 days' aging higher strength concrete is obtained.

It is beyond the scope of this paper to include a great number of test data, but in order to present the status of the existing information up to the present time the following brief summary is given.

1. All fly ash of the proper quality will benefit Portland cement compositions. The chief points of benefit are higher compressive strength, lower permeability, higher durability (freezing and thawing resistance), greater resistance to acid waters, improved appearance, lower bleeding rates, and higher workability.

2. A number of striking results have been obtained in the intergrinding of fly ash with Portland cement clinker. Up to 30% blends have been employed satisfactorily. The resulting product passes the specifications for pozzuolanic Portland cement and gives strength values equivalent to high early Portland cement.

3. Another very striking application for fly ash is in lean concrete mixtures. Fly ash has been employed in such mixtures either as an additive or as a replacement for sand in amounts up to 20 to 30% of the sand with a great improvement in strength and other properties.

4. Fly ash has been found to benefit rich concrete mixtures although not to the same extent as the leaner mixtures. It may also be used as an additive to the fine aggregate or as a replacement of sand although, due to the higher cement factor, the optimum percentage is lower than for the leaner mixtures.

5. Fly ash may be used to replace Portland cement and many of the existing data illustrate this use. However, this is not necessarily advocated since the simple addition of fly ash to a concrete mix results in an increased yield of concrete. Also since the performance of concrete is important, fly ash may be used to give improved performance, using the same cement factor in the mixture. Table III illustrates the type of results obtained from concrete in which 100 pounds of fly ash is used to replace 1 bag of Portland cement per yard of concrete.

6. Fly ash may be used with either normal Portland cement or air-entrained Portland cement, and recent work indicates that Portland cement containing both air-entraining materials and fly ash gives a superior concrete with unusually good strength and durability characteristics.

7. The type of Portland cement product that may be benefited with fly ash is varied in scope and may be illustrated by the following examples:

Table III. Comparison of Flexure Tests on Concrete Beams vs. Compressive Strength of Concrete Cylinders (Fly Ash vs. No Fly Ash)*

PROPORTIONS:

Quantities of Materials per Cubic Yard

Ingredient	*Regular concrete*	*Concrete with fly ash*
Cement	564 lb. (6 bags)	470 lb. (5 bags)
Fly ash	None	100 lb.
Sand (dry)	1325 lb.	1325 lb.
Dolomite Stone 2 in. to No. 4 (dry)	2020 lb.	2020 lb.
Total water	35 gal.	35 gal.
Actual slump	3 in.	3 in.

Compression cylinder size—8 in. diam. by 16 in. high
Beam size—6 in. × 6 in. × 24 in.

RESULTS:

Regular concrete				*Concrete with fly ash*			
Spec. No.	*Age, days*	*Total load lb.*	*Unit load, psi*	*Spec. No.*	*Age, days*	*Total load, lb.*	*Unit load, psi*
Compression Test of 8 × 16 in. Cylinders							
6001	7	138,000	2745	6005	7	176,000	3497
6002	32	238,560	4742	6006	32	252,990	5029
6003	94	290,710	5779	6007	94	266,610	5304
6004	181	289,840	5762	6008	181	294,360	5852
Flexure Test of 6 × 6 × 24 in. Beams							
6009	7	4,970	460	6013	7	5,295	490
6010	28	6,970	629	6014	28	6,335	587
6011	95	6,430	595	6015	95	5,980	554
6012	181	9,650	893	6016	181	8,150	755

* Courtesy of H. A. Frederick, Public Service Electric and Gas Company Testing Laboratory, Maplewood, N. J.

Ready-Mixed Concrete. When used with a standard 5- or 6- bag mix, fly ash may be employed in amounts up to 25% of the sand with very beneficial results for general foundation, highway, and other work.

Concrete Sewer Pipe. Addition of up to 25% fly ash based on the Portland cement content has been found to give superior pipe in respect to strength, permeability, structural and surface soundness, better appearance, (and also increased production).

Concrete Building Blocks. The introduction of fly ash fines in concrete masonry units has been found to give excellent results both in laboratory tests and in the field.

Cinder Blocks. Introduction of fly ash into cinder blocks has in many instances made this type product a first-class masonry unit as compared with a poor low-strength product. The introduction of the fines in many of these compositions is quite beneficial. In cases where cinders with high percentages of fines are employed, large additions of fly ash cannot be used. Other lightweight aggregates such as Haydite and Waylite have also been used beneficially with fly ash–Portland cement products.

Burial Vaults. Fly ash in burial vault concrete has been found to give better workability, less bleeding, higher strength, more attractive surfaces, and results in easier stripping of the mold from the concrete. Many of these vault compositions employ concrete of 4000 to 6000 pounds per square inch compressive strength.

Boiler Slag

The use of boiler slag, particularly in the Philadelphia area, as an additive for masonry units has been progressing very favorably and at the present

Table IV. Use of Fly Ash in Light Weight Block

MIXING PROPORTIONS:

Proportion by Weight				
Portland cement	*Waylite slag*	*Boiler slag*	*Fly ash*	*Fly ash agg. basis, %*
94	140	246	0	0
94	140	246	38.5	10
94	140	246	77.0	20
94	140	246	116.0	30
94	186	330	0	0
94	186	330	51.7	10
94	186	330	103.0	20
94	186	330	155.0	30

RESULTS:

Water cement ratio	*Density lb./ cu. ft.*	*Total volume per batch basis: 1 bag of cement, cu. ft.*	*Compression Strength 7 days P.S.I.*	*Number of blocks per bag cement (3 holes)*
0.76	104.0	5.04	1283	18
0.76	104.6	5.52	1382	20
0.86	107.5	5.83	1648	21
0.95	108 0	6.24	1612	22.5
1.40	92.6	7.32	667	26
1.40	97.9	7.52	928	27
1.50	98.2	8.12	960	28.5
1.70	101.5	8.44	1111	30

time there are approximately forty plants using this material either alone or with fly ash as part of the aggregate composition. Table IV illustrates the type of results that are obtained when fly ash and slag are used in a lightweight (Waylight) cinder block. Table V shows the type of results obtained on a standard concrete building brick tested in accordance with A.S.T.M. methods. This brick is made up of a composition containing 1 bag of cement, 60 pounds of fly ash, and 240 pounds of boiler slag. No other aggregates were used. These two tables are illustrative of many tests that have been run.

Specifications

In view of the outstanding success of the use of fly ash and boiler slag in concrete and of the recent research developments in this field, it has become evident that recognition of the proper use of this material by the various State Highway Departments, A.S.T.M. committees, and other similar agencies is warranted. With this in mind a complete compilation of the existing data, both published and unpublished, has been prepared and submitted to several State organizations and also to four A.S.T.M. Committees. Active efforts are being made to set up specifications for fly ash in concrete with these various groups.

Table V. Tests of Concrete Brick

Submitted by: Northeast Constructors, Craig & Stanwood Sts., Philadelphia, Pa.
Description: Dense, cement colored—Standard concrete brick dimension
Composition: 94 lb. Portland cement
60 lb. Fly ash
240 lb. Boiler slag
Method of Test: A.S.T.M. Standard Method C67–44

Results:

		Absorption			
	Modulus of rupture p.s.i.	*24 hr. at 70°F. % dry wt.*	*5 hr. boiling % dry wt.*	*C/B Ratio*	*Strength in compression p.s.i.*
1	630	12.6	17.7	0.712	2985
2	880	13.1	17.4	0.753	2765
3	805	10.7	16.0	0.670	3620
4	845	10.1	14.3	0.707	4830
5	615	13.7	18.2	0.754	4270
Av.	755	12.04	16.72	0.719	3694

These specimens meet the requirements of the A.S.T.M. Specification for Concrete Building Brick A.S.T.M. Designation C55–37. Grade A.

These specimens meet the compressive strength and absorption requirements set forth in A.S.T.M. standard specification for Building Brick (made from clay or shale) A.S.T.M. Designation C62–44. Grade SW.

OTHER APPLICATIONS

A number of other applications are being investigated for possible uses of fly ash. Some of these offer only limited use but others may very easily result in large tonnage consumption. The following list is not complete but illustrates the type of applications that are being studied.

Bituminous Paving

The use of fly ash as a filler in bituminous pavements has been gaining ground during the last few years. The cities of Detroit, and Flint, Michigan, have used fly ash as a replacement for limestone dust filler with good results. Both of these cities have approved specification for the use of fly ash in this service. In addition the State of New Jersey Highway Department has recently approved specifications for fly ash as a mineral filler for use. Quite a few applications have been made of bituminous mixtures using fly ash and the performance of the pavement has been found to be excellent. Most of the applications are at points where severe climatic changes are expected and where the pavements are subjected to heavy traffic conditions. A number of State Highway laboratories along the Eastern seaboard are participating in a program being conducted by the American Road Builders Association relative to the use of fly ash in road building.

More recently tests have been carried out in the Philadelphia area on boiler slag as an aggregate in bituminous pavement mixtures. While this use has not yet developed to a commercial outlet stage, a number of test roads have been laid and performance of the material has been found to be quite good. In comparison with standard mixtures the boiler slag aggregate seems to hold up equally well and in fact was found to work somewhat easier during the application of the material.

Asbestos Cement Products

Laboratory tests show that fly ash may be used to replace many of the fillers now employed in this type of product and plant tests are under way to further evaluate possibilities in this field.

Pressure Grouting

The use of fly ash in grouting compositions is developing as a favorable outlet and several railroads are beginning to use materials containing small amounts of fly ash. Recent tests in the laboratory show that considerably higher amounts of fly ash can be used beneficially for this application.

Lightweight Aggregates

There has been a good deal of activity in the development of lightweight aggregates from fly ash and boiler slag. One plant has been erected which uses fly ash, and it is understood that some material has been produced. A number of studies are also

under way to reduce the weight of the boiler slag. Methods of quenching the molten material and the effect of additives during the quenching period are being studied.

Miscellaneous Uses

Other important applications that are being studied either in the laboratory or in plant tests include fender undercoat compositions, sewage treatment processes, roofing compositions, the use of fly ash in metal polishing, the use of boiler slag in grinding compounds and in grinding wheels, preparation of acidproof cements, manufacture of rock wool, development of hydraulic cements and masonry cements, and the use of processed fly ash as a filler in rubber. Several of these fields are already using fly ash in small amounts.

HANDLING OF FLY ASH

One of the large problems involved with the commercial use of fly ash is the question of how it should be handled. For those applications where the material must be used in dry condition the problem is particularly difficult because fly ash has a very noticeable ability to dust and disperse throughout the air. The usual unloading equipment such as conveyors and bucket elevators cannot easily be used since the material will leak through the small opening of the equipment, flood through the conveyors and discharge into the atmosphere. Supplying fly ash in paper bags is one way of overcoming the dusting condition, but the cost of the material is increased markedly.

For those applications where dry fly ash is used in bulk, the prevention of leakage and flooding requires either very careful design of the unloading equipment or the installation of special unloading equipment which is designed specifically for a material of this type. The Fuller Kenyon and other air conveyors have been found to perform quite well. However, this type of unloading equipment is somewhat more expensive. In addition, the consumer usually has equipment already in position for unloading his fine material and is, there, somewhat reticent about installing additional equipment.

Certain applications of fly ash are suited to the use of moist material. Nearly all of the suppliers of fly ash have provided means for wetting down the material to reduce the dusting as it discharges from their plant. This product handles quite well in bulk and may be shipped in trucks and cars. It is not a satisfactory material, however, for bags. The wet product works very well in those plants where the material is not required to pass through too much mechanical equipment but where chutes, elevators, and conveyors are used the wet product has a tendency to stick—requiring the use of vibrators, air jets, and other devices in order to assist the flow.

For those applications where fly ash and boiler slag are used together, such as in masonry building units, a mixture of the two materials has been found to be very adaptable for bulk handling. Moistened mixtures of fly ash and slag can be transported readily and do not stick in conveying equipment.

As mentioned previously, the information presented in this paper is merely indicative of the type of problems that are being studied in this field.

As the months and years roll around and the information gradually piles up on the uses of fly ash, and boiler slag, it is evident that these materials will continue to grow in popularity and that the widespread consumption of these products is ultimately assured. It is also evident, however, that much additional research work must yet be carried out and that many problems still remain to be solved.

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The Use of a Roberts Grinder for Manufacturing Different Grades of Groundwood

ROBERT S. MAGRUDER

A short description of the Roberts grinder is given to familiarize the reader with construction features. A series of tests were run on commercially operating Roberts grinders to determine the operational characteristics for this type of grinder. The effect of stone surface age, power input (grinding pressure), grinding temperature, and burrs used on the dependent variables of production, power consumption, fiber classification, and strength are discussed. The application of this information for the manufacture of several grades of groundwood pulp is demonstrated.

To A PLANT engineer, a pump is worth only as much as the operational characteristics indicate. The same may be applied to a grinder. To the prospective buyer or to the mill superintendent, the operational characteristics of the grinder are essential for intelligent operation. With the installation of the Roberts grinders at St. Regis, it was necessary to determine what the operational characteristics were for economical pulping. It is the purpose of this paper, therefore, to present operating curves to indicate how they were applied for the manufacture of book pulp paper and, in addition, to demonstrate how the grinder might be operated to produce board, book, or other grades of groundwood pulp.

CONSTRUCTION OF ROBERTS GRINDER

The distinguishing feature of a Roberts grinder is the massive feed ring (9 feet inside diameter) revolving slowly in the same direction as the stone and located eccentric to the stone such as to form a "crescent-like" pocket. The tip of the crescent is at a point 45° forward of the vertical center line of the stone. There is reason to believe that little or no grinding takes place in the pocket above the horizontal center line of the stone. Therefore, the active angular grinding area is 135°—or when grinding 4-foot wood, 26.5 sq. ft.

In reality the feed ring is made up of an inner ring and an outer ring. The distance between the two rings, amounting to 3 inches, serves as a stock discharge. The inner ring is perforated with large holes through which the stock drops to reach the space between the two rings. Coarse teeth on the inner surface of the inner ring bite into the wood and move it into the grinding zone. The movement of the ring plus the friction between the stone and the wood furnish the grinding pressure. Comparing the Roberts with the old three-pocket grinders on which pressure could be calculated and pointing out that the power consumption for each type is the same, a unit pressure of 33 p.s.i. for the Roberts is found. To the outer ring is fastened a steel worm gear which meshes on top of the grinder with a bronze worm. Through this worm is transmitted the revolving force to the feed ring. In addition, on the outer surface of the ring near each edge are two machined grooves extending completely around the ring. The ring rides on several Ryertex bearing blocks ground to the same radius as the machined grooves and mounted in the lower half of the grinder case. These bearing blocks serve as both radial and thrust bearings.

A Vickers Hydraulic Power unit coupled with a fluid motor furnishes the driving force for the ring. Constant oil flow from the power unit at 800 p.s.i. pressure passes through a tee. One side of this tee leads to the fluid motor; the other side to the master cylinder. As the master cylinder opens, more oil flows through it and consequently less through the fluid motor, causing a decrease in the speed of the motor. Conversely as the master cylinder closes, the fluid motor picks up speed.

The action of the master cylinder is controlled by a Waterous Electric Load Governor. Through this governor it is possible to control the load on the grinder (the grinding pressure) by a twist of a knob.

The pulpstones are, of course, artificial. Both Norton and Carborundum stones are in use at the present time. The stone has a 54-inch face and 60 inches in diameter. This means that at 240 r.p.m. a peripheral speed of 3770 f.p.m. is obtained from a new stone. As several grades are manufactured, stone life varies somewhat. These first stones will average 700 to 900 days or better than 20,000 tons each. The second set of stones should go 1100 to 1200 days or 28,000 to 31,000 tons. Light dressing and an 80-hour burring cycle contribute to this stone life.

The shaft bearings are water-lubricated Ryertex bearings. Differing from other grinders, the thrust of the shaft is directed upward against the top half of the bearing. It is interesting to note that the direction of the thrust is about 22.5° from the vertical center line of the shaft and in the direction of the rotation of the shaft.

There are seven Roberts grinders at the Deferiet Mill. Each grinder is connected to a 2000 h.p., 240 r.p.m. synchronous motor through a "floating" shaft with a No. 9 Koppers coupling on both the grinder and motor ends. Wood is conveyed to the grinders in a steel, water-filled trough running the full length of the grinder room. A 2000 g.p.m. circulating pump creates an artificial current to move the wood forward in the trough. There is one grinderman for each

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grinder. For comparison, each Roberts grinder replaced four three-pocket grinders and from a labor standpoint one operator produces what three men formerly produced.

EXPERIMENTAL PROCEDURE AND RESULTS

The accomplishment of experimental work under actual operation conditions is exceedingly difficult. The laboratory technician is able to isolate his work. Should his experiments produce extreme results there is no harm done. Nothing else is affected. However, it is quite different in a commercial pulp mill. To maintain the high standards required on a competitive market, paper must be of the highest quality—hence the pulp from which it is made must be the best possible to produce. As a result, in these experiments it was impossible "to go out on a limb" too far. The resulting pulp had to be consistent with salable paper. The second problem was the control of the wood during the time a trial was actually in progress. As wood from several sources is ground, it was necessary for each trial to wait until a standard mixture of wood was being ground. The so-called "standard" mixture was composed of 70% Canadian spruce and balsam from the north shore of the St. Lawrence at a moisture of 40% A.D. and a density of 29.5 lb. per cu. ft. and 30% local spruce with a 45% moisture A.D. and a density of about 24 lb. per cu. ft. This mixture was used throughout the test runs.

The experimental work reported here was conducted on one grinder. The same work was accomplished on other grinders but for sake of clarity only the results found on the one grinder will be discussed. Regardless of the grinder used, the resulting curves had the same characteristics and slopes—the only difference was an occasional displacement either upward or downward.

The following variables remain constant and the following units are used throughout unless otherwise indicated. The stone was an 82 grit Carborundum (C82C4L7V). It had been run about 550 days at the time these experiments were conducted and was traveling at 3600 f.p.m. The dressing was a 16-cut, 2-inch lead burr with a normal burring cycle of 80 hours. A Taylor temperature controller maintained a temperature of 150°F. at a pit consistency of approximately 2.5% A.D. Production was measured on the basis of the ring speed (standard mill practice) and expressed as both tons per day and tons per square foot per day. Power was determined on a totalizing wattmeter.

A fractionization of each stock sample was run on a Bauer-McNett classifier preceded by a 0.014-cut laboratory flat screen. All strength test pulp was first screened over the 0.014 flat screen prior to sheetmaking. A Williams sheet mold with an 80-mesh wire was employed for the making of the 60-pound (24 × 36—500) hand sheets.

The strength tests were run on conditioned hand sheets and physical tests were in accordance with TAPPI standards. Results were expressed in the following units: bursting strength as per cent points per pound, tear as per cent grams per pound, tensile as per cent pounds per pound per one-half inch strip and freeness as a Schopper-Riegler "beating degree." One additional physical factor has been included that has no TAPPI recognition. It is the bulk number and is determined as the caliper of eight test sheets divided by eight; the result divided by the true basis weight and the result multiplied by ten. It has been found that a bulk number of 1.30 for groundwood pulp makes an excellent book sheet.

Effect of Stone Surface Age

First consideration was given to the surface of the stone. Since the stone itself, the peripheral speed and the burr used (16-cut, 2-inch lead) remained constant the only variable was the age or elapsed time since the the stone had been sharpened.

The procedure used was to wait each morning until a standard mixture of wood was being ground. The load then adjusted to 1400 kw. (1875 h.p.) and the temperature controller checked for a reading of 150°F. ±5°. The totalizing wattmeter was then read as was the production counter. Close watch was kept of the grinder for 5 hours, at the end of which time the meters were again read. These data furnished the power consumption and production figures for the period. At some convenient time during the 5-hour run, a sample of stock was selected. The exact time of selection was noted carefully as this was taken as the "age" of the surface of the stone for the particular run. This was repeated each day for 2 weeks.

The usual burring cycle is approximately 80 hours but for sake of completeness the stone ran 121 hours before being resharpened.

The production and power consumption curves as the age of the surface increases may be seen in Fig. 1.

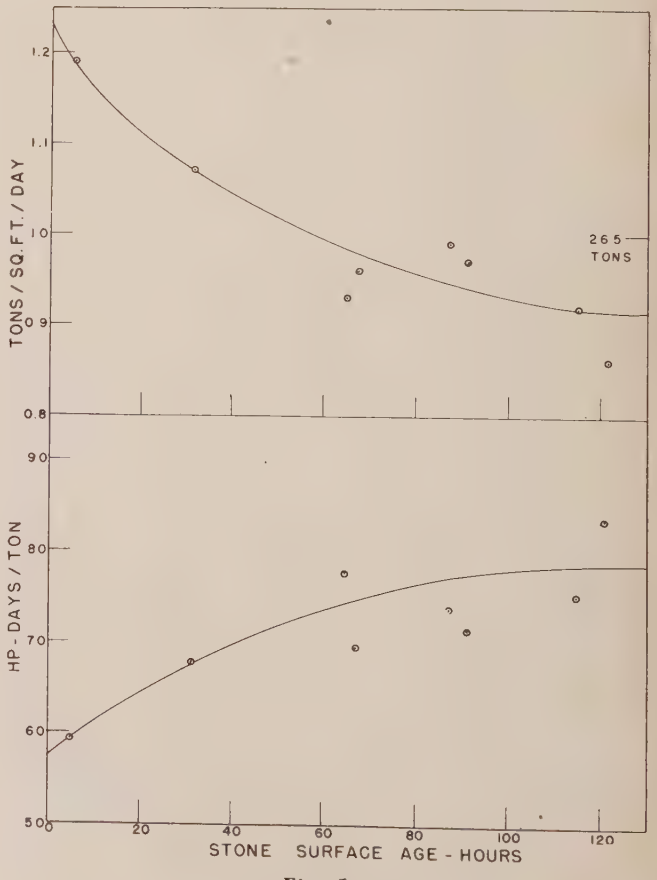

Fig. 1.

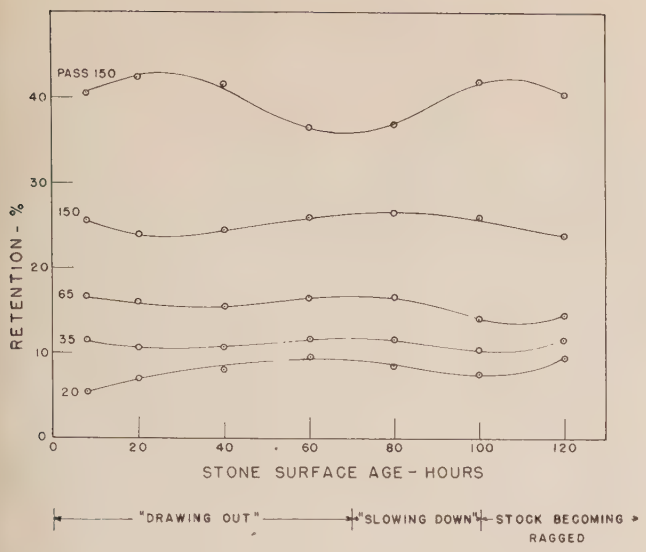

Fig. 2.

The greatest production immediately after sharpening amounts to almost 33 tons per day (1.24 tons per square foot per day) at a power consumption of 56 h.p.-days per ton. It will be observed that both curves tend to level off about 60 hours of wear. Even at the end of the 120-hour period, the production has only fallen to 0.9 ton per square foot per day or to about 24 tons per day with a power consumption of 78 hp.-days per ton.

As for the physical characteristic of the fiber produced during this period, refer to Figs. 2 and 3. Figure 2 shows the classification changes during the 120 hours aging period. Of particular interest is the 20-mesh fraction curve. It demonstrates quantitatively what is observed in the blue glass. Immediately after sharpening the stock looks short and "sharp." As time progresses the fiber "draws out." Observe in Fig. 2 the 20-mesh retention increasing with age from 5% at 8 hours to almost 10% at 60 to 70 hours. Again to the blue glass to observe after 60 to 70 hours a gradual shortening of the stock. Actually this "shortening" period lasts some 30 hours. The surface of the stone has disappeared entirely by 100 hours and the grinding operation begins to produce a "ragged" stock. The sharp increase of the 20-mesh fraction from 100 to 120 hours demonstrates this fact. Essentially, the same changes will be observed in the 35-, 65-, and 150-mesh fractions, although the 150-mesh fraction lags the 20 mesh by 20 to 30 hours. As would be expected, the "flour" or fraction passing 150 mesh decreases to 60 to 70 hours, increases to 100 hours, and decreases again as the long ragged stock is being produced after 100 hours.

For the effect of surface age on the strength of the resulting pulp, refer to Fig. 3. The bursting strength and tensile parallel each other rather closely. In each case age improves the strength with no tendency even to level out. The leveling out portion of each curve is assumed to come with an excess of 120 hours of wear.

The tear exhibits a rather interesting curve which parallels very closely the curve for the 20-mesh retention as discussed in Fig. 2. It substantiates former beliefs that the amount of long fiber present governs the magnitude of the tear.

That the bulk number is closely related to the amount of short broken fibers is clearly demonstrated by reference again to Fig. 2. Note the very close wave pattern between the 150-mesh retention and the bulk number curve. In each case there is a minimum point at 30 hours and a maximum point at close to 80 hours.

With reference to the freeness curve in Fig. 3 it is noted that after 60 hours little or no change occurs in the freeness. With all other physical factors changing a corresponding change in freeness might be expected. A possible explanation is that the stock is so slow (Schopper-Reigler 83 or Canadian Standard 40) that the operation of the freeness tester is sluggish and therefore not especially reliable in this extremely low range. It does demonstrate that in these lower ranges freeness is not a good criterion for strength.

Considering all factors in the above discussion and weighing production against power consumption and strength, it can be concluded that a burring cycle of 80 hours is optimum. To prolong the cycle means increased strength at the expense of power consumption and production. To sharpen a stone too frequently means higher production at less power per ton with a resulting pulp that is far too weak for a good sheet of book. In actual operation this is borne out. For the first six months of 1948 the Roberts grinders at Deferiet were sharpened on an average of once every 78 hours.

Effect of Power Input or Total Grinding Pressure

In the preceding discussion of surface age the power input to the grinders was held constant. The investigation of the effect of power input was the next step. That the power input and the total grinding pressure are directly related goes without saying. It is also a

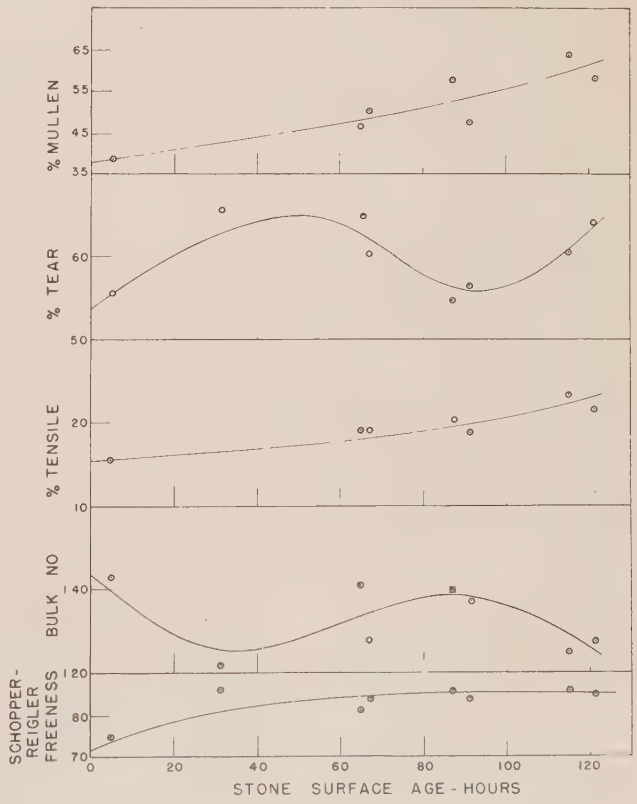

Fig. 3.

well-known fact that as the pressure increases, the production will also increase. There was interest, however, in the magnitude of such changes, the actual power consumption per ton of pulp, and the over-all effect on the physical characteristics of the resulting pulp.

The procedure was to first select the time in the aging cycle of the surface of the stone which would represent an average condition. After inspection of Figs. 1, 2, and 3 it was elected to run all power input tests at 60 hours of stone surface age. It was also necessary that the standard mixture of wood being ground should coincide with the 60-hour period. A temperature of 150°F. and a surface which had been sharpened with a 16-cut, 2-inch lead burr were used as in the preceding tests. Four runs were made—the first at 100-kw. power input, a second at 1200 kw., a third at 1400 kw., and the fourth at 1600 kw. Each run lasted three-quarters of an hour during which time power production readings were taken and at the end of the period a sample of the stock was selected for classification and physical tests.

Figure 4 represents the power and production curves for this run. It will be noted that the production varies in a linear fashion. At 1000-kw. (1340 hp) power input the production is only 0.35 ton per square foot per day or 9.3 tons per day on the Deferiet Roberts. This increases with a constant slope to 1.41 tons per square foot per day at 1600 kw. (2145 hp.). Within the range of 1300 to 2200 hp. the production change amounts to 4.69 tons per day per 100 kw. This is the curve as determined by experiment. It checks very well in actual practice, however. For the first six months of 1948 Roberts grinders were operated at 1875 hp. and produced for the same period 26.2 tons per stone per day. The experimental results show for 1875 hp. a production of 26.7 tons per day.

That it is not economical to operate a Roberts grinder at extremely low pressures is illustrated in the power consumption curve of Fig. 4. Notice at 1000 kw. (1340 hp.) the consumption of power amounts to almost 150 hp.-days per ton. As the power consumption per ton drops very rapidly until at 1875 hp. we are down to 70 hp.-days per ton and at 2150 hp. (an overload on the 2000 hp. motors) the power consumption has dropped to 57 hp.-days per ton. Here again the experimental curve checks very well with operational averages. During the six-month period previously mentioned, an average of 69.6 hp.-days per ton was obtained while operating at 1400 kw. and the experimental data indicates 70 hp. at the same power input.

The fiber classification for the power run is shown in Fig. 5. It is interesting to note that the 35- and 65-mesh fractions remain constant regardless of the power input. The 20-mesh fraction shows little change up to and including the 1875 hp. point but increases almost 100% with the next power increase of 200 kw. This radical increase in the 20-mesh fraction at this point has appeared in the classifications of other stones undergoing the same tests. The 150-mesh fraction drops sharply between 1340 hp. and 1610 hp. but remains uniform for the remainder of the run.

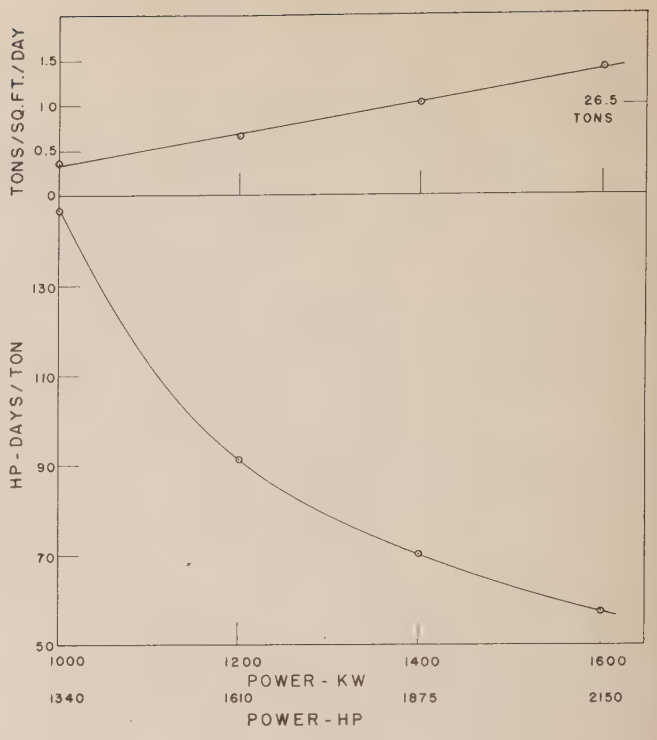

Fig. 4.

The strength of the pulp varies a great deal more with changes in power than the classification curves in Fig. 5 might indicate. With reference to Fig. 6, the bursting strength at 1340 kw. is high but as the power input (grinding pressure) increases the burst drops off rapidly with the slope of the curve becoming increasingly steep with additional power. The burst drops a full ten points when the last 200 kw. of power is applied. The tear and tensile show little change—the tear increasing sharply between 1340 hp. and 1610 hp. and remaining constant for the remainder of the run. The tensile, on the other hand, does not fall off until the last 200 kw. of power is applied. The bulk number exhibits rather decided tendencies. It will be noted that as the production curve varied in a linear fashion, so does the bulk number curve. The The slope of the curve is uniform and increases with increasing power. In the manufacture of groundwood

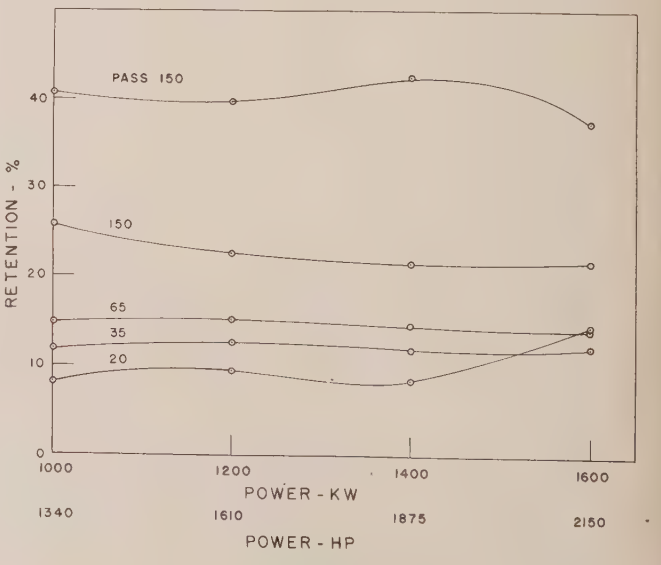

Fig. 5.

pulp for book papers this point is rather important and should be borne in mind. The freeness curve varies in much the same manner as does the curve for bursting strength. And here again the slope of the curve becomes increasingly steep as additional power is applied.

From the above discussion it can be concluded that at low power input (low grinding pressure) excellent strength with low bulk may be expected. The pulp would be excellent for a book grade. However, the power input is so high and the production so low that economical operation is impossible. To go to the other extreme and grind at high pressure (2150 hp. input) results in good production at a low power input per ton. The resulting pulp, however, has low strength and a bulk number so high as to make the pulp virtually worthless in the production of book papers. Power input (grinding pressure) has more influence on bulk number than any other variable once the wood supply is constant and surface pattern established. The knowledge of this fact is extremely important to the groundwood superintendent. It is quite often possible to lower a high bulk number caused by a few cords of poor wood by reducing the power input a small amount.

A knowledge of the characteristic power input curves is important. Full load on the Deferiet grinders is 2000 hp. or 1500 kw. Operation at this point for about a year gave a production of slightly better than 30 tons per day. The resulting pulp, however, was a little too bulky and was giving the papermakers some trouble. It was decided that it would be well worth while to sacrifice production for

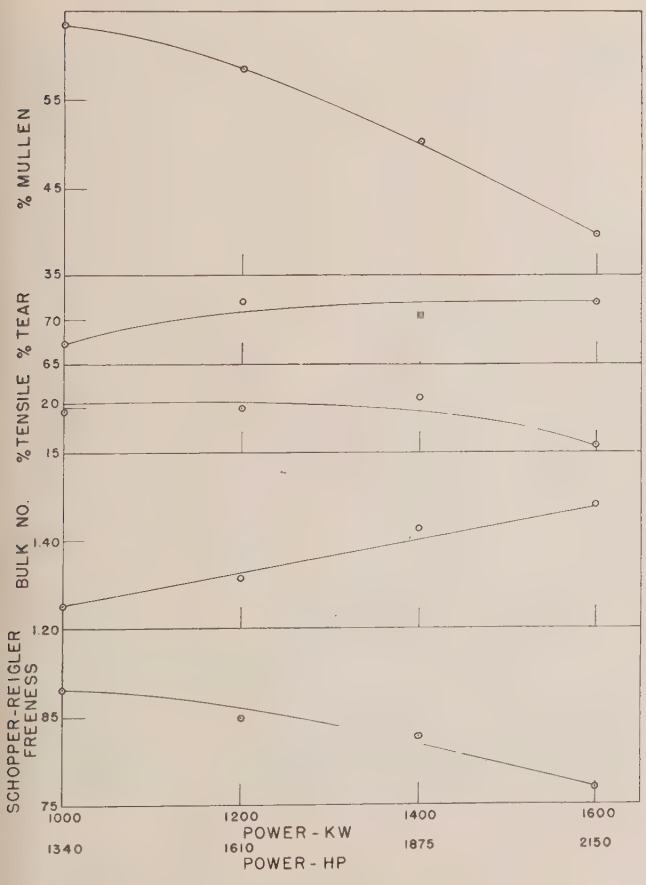

Fig. 6.

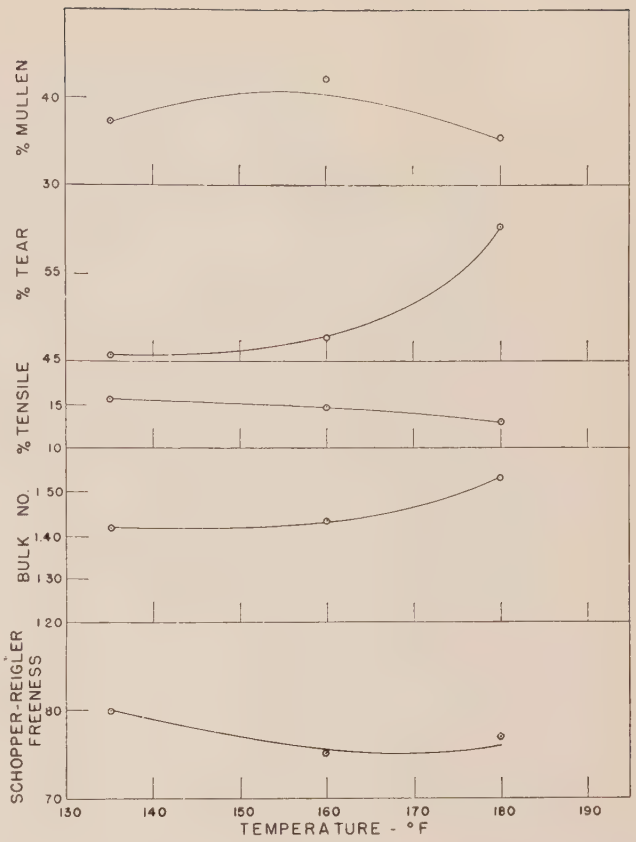

Fig. 7.

a lower bulk number. This was done and the load reduced to 1875 hp. with immediate improvement in pulp quality. The production as a result was lowered to 26 tons per day. From an operational standpoint this reduction in power improved screening considerably. In doing so advantage was taken of the drop in 20-mesh retention (see Fig. 5) when lowering the power from 1500 to 1400 kw. Screen plate breakage dropped 50% with the application of the lower power.

Effect of Temperature

Because of difficulties encountered in maintaining a constant temperature below 140°F. and above 170°F. for prolonged periods, it was impossible to investigate power and production variables. Therefore, the temperature investigation was limited to strength characteristics only.

The test conditions involved use of the standard mixture of wood, grinding being done when the stone surface was at the desired 60-hour age. The load was adjusted to 1400 kw. and the stone flooded with water. As a result the temperature was lowered to 135°F. The grinder was permitted to operate in this fashion for a short period before a stock sample was selected. The temperature was then raised to 160°F. and finally to 180°F. by decreasing the amount of shower water.

Figure 7 plots the various strength elements against temperature. In each case with the exception of freeness little or no change occurs between 135 and 160°F. The stock in this range of 25° does "free up" about 5 Schlopper-Reigler degrees. Rather sharp changes took place when the temperature was raised to 180°F., however. This was particularly true with the tear and the bulk number. The tear which had held in

the vicinity of 47% for both the 135 and 160° points increased sharply to better than 60% at 180°. The bulk number reacted in the same manner. From the appearance of the stock coming over the dam little change in production occurred between 135 and 160°. At 180° the production rose sharply as indicated by the appearance of the stock flowing over the dam.

From the standpoint of the "book pulper" the results of the above investigation indicate that the grinding temperature should be kept below 160°F. As far as temperature is concerned, this will assure one of a low bulk number.

Effect of Stone Surface Dressing

As has been discussed earlier, it is essential that pulp quality remain uniform. It was therefore impossible to conduct an extensive investigation of the effect of various burrs on pulp quality and production. A great deal has been done in the past regarding this phase of pulping but in each case the change was minor and considerable time elapsed between burr changes. It is therefore virtually impossible to present any comprehensive study of this problem.

Table I. Effect of Stone Dressing on Strength

	Burr, 14-cut, ½-in lead	*Burr, 16-cut, 2-in. lead*
Bursting strength, %	33.2	62.1
Tear, %	76.0	68.6
Tensile, %	16.2	22.5
Freeness, S. R.	62.5	80.5
Bulk number	1.68	1.25

An indication of the importance of proper stone dressing may be had by inspection of Table I. These particular data were taken from tests run on a 77-grit Alundum stone grinding local (New York State) spruce at 1875 hp. The changes in this case are quite drastic and of much greater magnitude than is usually the case. The initial problem was to reduce the bulk number of stock produced on two Alundum stones. The change made was to replace the 14-cut, $^1/_2$-inch lead burr with a 16-cut, 2-inch lead burr. The results of the change clearly indicate what can be done. Not only was the bulk reduced to an acceptable point but the bursting strength was almost doubled. The tear remained high, and the tensile improved about one third. The production as a result of the change was not effected to any marked degree. A small decrease may have occurred but the improved cleanliness of the stock offset this with a higher percentage of acceptable fiber.

Table II. Effect of Combination of Stone Dressing and Power Input on Strength

	2000 Hp., 14-cut, 1¼-in. Burr	*1875 Hp., 16-cut, 2-in. Burr*
Bursting strength, %	46.2	56.4
Tear, %	55.3	61.9
Tensile, %	15.9	21.0
Freeness, S. R.	78.5	83
Bulk number	1.49	1.31

Often a combination of surface dressing and grinding pressure are required to improve pulp quality. Table II illustrates what was accomplished by use of both of these factors. This change was made on an 82-grit Crystolon stone—the same stone previously discussed. Here again the problem was to reduce the bulk number. The initial change from a 14-cut to a 16-cut burr improved the quality but not of sufficient magnitude to rest.

The second step was to reduce the power input from 2000 to 1875 hp. This combination was successful in reducing the bulk number from a prohibited 1.49 to an acceptable 1.31. This loss in production amounted to 4 ton per day but from a pulp quality standpoint was well worth while—at least from the papermakers point of view. Reference to Table II will show the improvement in burst, tear, and tensile —all of which were incidental to the improvement in bulk number.

APPLICATION OF CHARACTERISTIC CURVES

Book Pulp

In the manufacture of mechanical pulp for book papers pulp quality is of prime importance. Within reasonable limits the production is of secondary importance. For a sheet of this type it is desirable to furnish a slow pulp of low bulk and high strength. The stock must be clean and well screened as anything that detracts from the finish of the sheet is not desirable.

Using the characteristics curves previously discussed, can it be shown that a Roberts grinder will produce this stock? With reference to Fig. 3 and the burring cycle it appears that the longer the period between sharpenings the greater the over-all strength will be. As cleanliness is important the stone should not be permitted to produce a "ragged" stock. In Fig. 2 the cycle should be cut from 120 to 100 hours because of this condition. Secondly, consider the production as shown in Fig. 1. At 100 hours the production has decreased to 24 tons per day at 78 horsepower days per ton. It might be well therefore to "sweeten" the production a small amount by decreasing the burring cycle from 100 hours to perhaps 80 hours depending, of course, on local conditions. The point to bear in mind when considering the burring cycle is to keep it as long as it's consistent with good pulping.

Next consider the power input or total grinding pressure. The strength characteristics of Fig. 6 indicate a low power input is conducive to high strength and a low (slow) freeness. The production (Fig. 4) is so low and power consumption so high at low pressure that economical operation at this point is virtually impossible. As a result a midpoint must again be chosen increasing the power input to 1875 hp. At this point the pulp is not as strong as at 1340 hp. but the strength is high enough to be consistent with good operation.

From the brief discussion of temperature it is evident that most any point between 140 and 160° will produce the desired quality. It is detrimental, however, to exceed 160°.

Stone surface dressing for book pulps depends on local conditions so much it is difficult to say anything definite. Indications (Table I) point to a rather fine burr—a burr that will produce a pulp, the classification of which will be distributed evenly over the several fractions.

It is apparent from the above that a Roberts grinder will produce a good grade of book stock. In fact several mills today are using their Roberts to produce this type of mechanical pulp.

Application to Pulps Other Than Book

The preceding discussion has been based on experimental work carried out in a book pulp mill. It is a fair question to ask whether or not the same type of grinder under different grinding conditions would produce the same characteristic operational curves. It has been demonstrated that the Roberts grinder will produce a good grade of book pulp but will the same grinder produce news or board pulp?

As evidence that the Roberts will produce other grades and that the curves previously discussed will, in general, apply to news, board, or other types of pulp, refer to Fig. 8, which is a plot of power input as against production and is a correlation between the experimental work accomplished and actual operating conditions. Curve A is a replot of the data from Fig. 4 which showed the effect of power input on production. Hence curve A is the experimental curve. From information furnished the author regarding production of several other mills using the Roberts grinder, curve B has been drawn. Three mills fall on the curve very nicely. The first, a slow book grade mill producing 26 tons per day at 1875 hp.; the second, another book grade mill, producing a freer pulp using 2400 hp. for 40 tons per day; and the third, a board mill grinding 60 tons per day at 3000 hp. It will be observed that curve B falls roughly parallel to curve A, indicating that the experimental results are not too

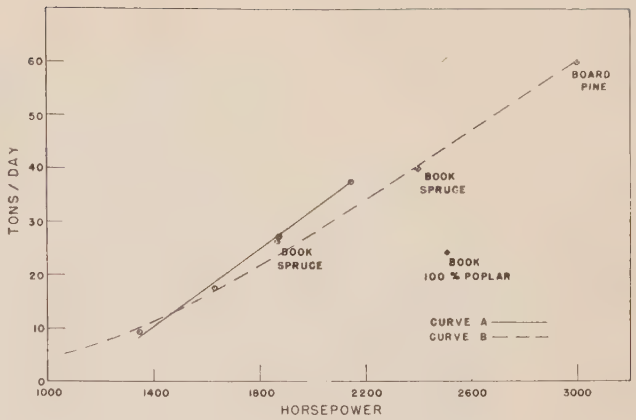

Fig. 8.

far out of line. One mill plotted on Fig. 8 does not agree too well with the experimental curve. In this case, however, the grinder is operating on 100% poplar and as such is not comparable to the experimental curve.

In conclusion, the Roberts grinder is a flexible machine capable of excellent production over a wide range of high quality pulp. The foregoing operational characteristics bear this out. No attempt has been made or will be made to compare the Roberts with other more common types of grinders. The reader, however, by using these operational curves will be able to make his own conclusions.

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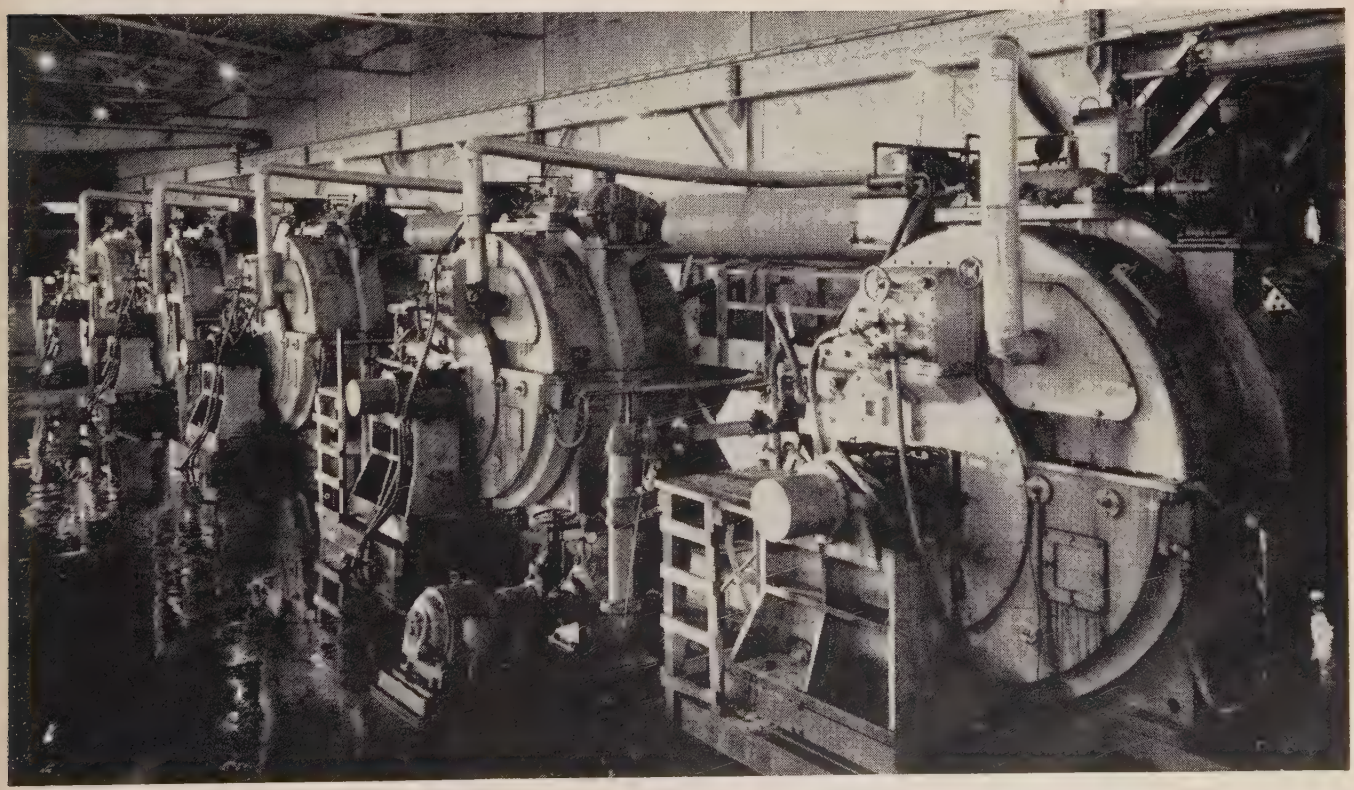

Fig. 9. Roberts Grinder Installation at the Deferiet Mill of the St. Regis Paper Company

Screening Groundwood Pulp

JOSEPH EDWARDS

Some general principles covering coarse and fine screening of groundwood pulps are reviewed briefly and, in the latter case, an attempt is made to draw a clear distinction between the requirements of primary and rescreens. The influence of consistency on the efficiency of the combined screening and deckering operation is discussed at length and illustrated by a description of two newly installed systems in large Canadian newsprint mills.

Some of the general aspects of groundwood pulp screening are discussed briefly referring to a few relatively recent equipment developments and, in particular, to two new screening installations in the author's company's mills. Thickening operations and white water systems will be dealt with only in terms of their relation to screening.

COARSE SCREENING

Coarse screening in the past was commonly effected in two stages, namely, by removal of shims, etc., in bull screens, followed by the removal of large slivers and long stringy material in knotter screens. Later, coarse screens were developed which served to achieve the two results in a single operation and, subsequently, even the older types of bull screen were frequently fitted with plates of finer perforation to the extent that, at the present time, single-stage coarse screening is a common practice in the industry. Generally speaking, the rejects from a single stage operation will be less than the combined losses from double-stage systems, certainly not more. The advantages of the single-stage system are obvious—reduced floor space and equipment requirements and, frequently, the elimination of one pumping stage.

The main requirements of a good coarse screen are that it rejects the oversize material which would otherwise cause damage to the fine screens following or which cannot be reduced effectively by refining equipment. The screen should reject a minimum of good fiber, should not have a tendency to plug up rapidly under overload, and be of such design that its efficiency and capacity are not impaired by increasing input consistency to at least 1%. This last requirement has assumed greater importance in recent years since the appearance on the market of fine screens which operate most efficiently at high consistencies.

Several types of coarse screens meet the above-noted requirements, and it would be pointless to describe all of the various makes in general use. Reference should be made, however, to the recently introduced vibrating (Jonsson) screen. Widely used as a knotter screen for chemical pulps here and in Scandinavia, tests have shown that it is equally effective as a groundwood coarse screen having a capacity of well over 100 tons daily at consistencies up to 1.25%. Power requirements are very low, and rejects are exceptionally free from good fiber. An additional advantage is the small space required for its installation.

This type of screen consists of a plate with approximately $^1/_4$-inch perforations, supported on a frame by four springs. The drive shaft, mounted on the frame, is equipped with two flywheels with unbalanced weights, and travels at approximately 1500 r.p.m. Accordingly, the screen in operation moves in a circular path of low amplitude, describing 1500 oscillations per minute. The pulp which is fed on to the plate is violently agitated so that accepted stock passes through without any tendency to form a mat and hence reduce capacity. Meanwhile rejects are forced, by the oscillating motion, to travel up over the dry portion of the plate where they are washed entirely free of good stock by two strategically placed showers, and then over the end into whatever means for their disposal that has been provided.

FINE SCREENS

Until quite recently, fine screening of groundwood pulp has been accomplished in two or more stages, usually with centrifugal rotary screens. Primary screening and the rescreening of primary screen rejects are essentially entirely different types of operation. Generally speaking, however, they have not been sufficiently recognized as such, and it is quite usual to see the same type of screen installed for both steps. In primary screening, there is a mixture containing about 95% of acceptable fiber and only 5% objectionable material. Freeness and average fiber length are low and the tendency to mat on the screen plate is relatively small. Therefore, it is not too difficult to achieve reasonably high throughput with a minimum of shower water dilution. The main purpose being the complete elimination of oversize material from the accepted stock, it is inevitable that considerable quantities of good fiber be rejected. It is the purpose of rescreening to reclaim as much as possible of this rejected good fiber. It is to be noted, however, that the nature of the ingoing pulp is entirely different. Instead of being lower in freeness and fiber length and containing only some 5% oversize fiber, it is very free, consists mostly of long-fibered material, and contains approximately 50% of fiber which must be rejected. In order to guard against the acceptance of objectionable fiber, screen perforations must of necessity be small, and the combination of high freeness stock and small perforations results in a tendency of the pulp to quickly form a mat on the plate. This tendency can only be overcome by providing large quantities of dilution water which, in turn, results in dirt and shives being washed through the plate. As a consequence, accepted stock from rescreens is usually relatively dirty and

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extremely dilute. Being dilute, a heavy burden is placed on the thickening equipment out of all proportion to the tonnages involved.

The problem of rescreening assumes varying importance, of course, from mill to mill. It is most acute where no refining equipment is installed and, as a consequence, where losses must be kept at a minimum. Refiners are used in a majority of mills, however, and in such cases it is permissible, and indeed good practice, to allow some good fiber to be rejected from rescreens in order to raise the consistency and improve the cleanliness of accepted stock. Still other mills have such low-grade product outlets for rescreen pulp as newsprint wrapper, etc., in which case the dirt count is of minor importance and, as a consequence, considerable liberty can be taken in the rescreening operation.

SCREEN TYPES

Centrifugal pulp screens for groundwood are of two general types, the first consisting of a rotating element with a fully drained screen plate, the tailings collecting at one end of the screen from which they are removed by bleeding a fixed quantity of stock. This usually amounts to up to 20% of the input to the screen. The

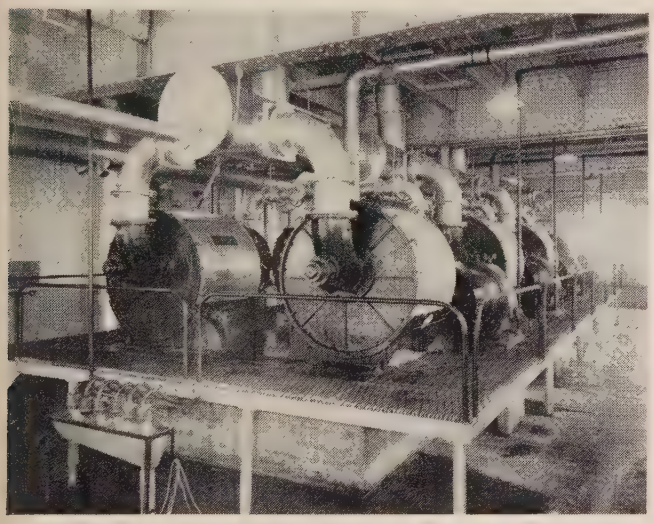

Fig. 1. Cowan Screen Installation at the Riverbend Mill

second type consists of a rotating element with free discharge of both tailings and accepted stock. The Quiller and Cowan screens fall into this category. Under proper operating conditions, rejects are considerably lower than is usual with screens of the first-noted type, and for the Cowan screen this is particularly true to the extent that rescreening becomes unnecessary. More detailed reference to this point will be made later.

Generally speaking, screen plates for primary screening have perforations about 0.065 inch in diameter, which is many, many times the diameter of fibers and even of large fiber bundles. Their passage through the screen orifices is prevented by the fact that they align themselves along the direction of travel of stock around the screen and, accordingly, are, in general, presented tangentially to the plate.

The capacity of a screen depends principally on the following factors: centrifugal force on the stock (peripheral impeller speed); size and number of perforations; consistency of feed and quantity of shower water added; percentage of tailings in feed stock; allowable quantity good stock rejected with tailings; and kind of stock, particularly fiber length and freeness.

In general, underloading of a screen results in good separation of accepted stock from tailings but at excessive horsepower per ton, while overloading results in the rejection of excessive quantities of good fiber and greatly increases the danger of plate breakage.

The coefficient of discharge for screen plates is exceedingly low being less than 10% of the usual value for orifices, and this low coefficient is due to the tangential flow of the stock and to the unfavorable flow conditions of the perforations. The latter can be improved by coating the metal plate with a smooth film, such as a thermoset phenolic plastic (e.g., Lithcote and Heresite), thus appreciably increasing capacity.

The Cowan Screen

The Cowan screen is an improved centrifugal screen of the Quiller type differing mainly in the impeller design and in the manner of adding dilution water. At approximately midway along its length, the impeller is fitted with a baffle through which tailings pass to the second half of the screen. Dilution water is added in this half only and is admitted to the stock *via* the hollow shaft of the impeller. Screen plates are graduated in perforation size, usually being 0.065 inch on the inlet or primary side of the baffle and 0.055 inch on the tailings side. In effect, therefore, the Cowan screen combines in one unit the features

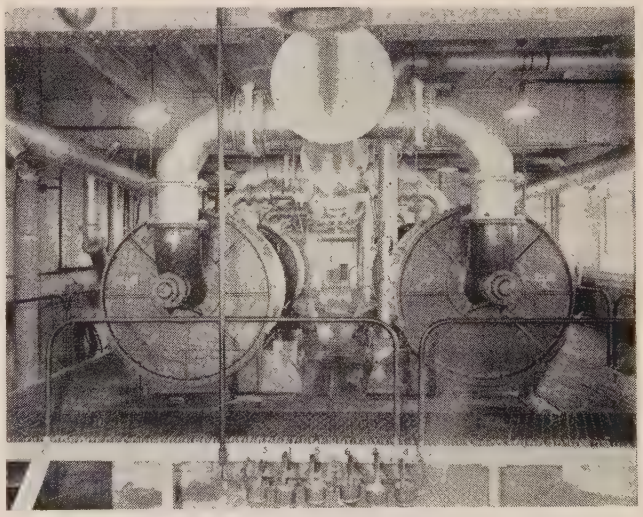

Fig. 2. Cowan Screen Installation at the Riverbend Mill

required for good primary screening and also for effective rescreening, and it is to all intents a combined screen. Moreover, the restricted use of dilution water and its application only where needed (to the thickened, free stock at the tailings end) result in a minimum drop in consistency through the screen. Very much less thickening equipment is required than would otherwise be the case, and there is a substantial shrinkage in the volume of the white water system as a whole.

MILL INSTALLATIONS

The remainder of this paper is devoted to a description of the first and second all-Cowan screen installations now in use. The first went into service at the Riverbend mill of Price Brothers & Company, Limited, in 1946; the second at the Kenogami mill of the same company in the following year.

At Riverbend, the capacity of the groundwood mill prior to the new installation was approximately 480 tons per day, and it was intended to increase this to 600 tons per day through the addition of grinders and auxiliary equipment. The screen and decker rooms were crowded so that it would have been necessary to erect a building of substantial size to accommodate the new screens and deckers required.

Meanwhile, the first full size (42-inch) Cowan screen had been built and installed at Riverbend as a trial unit. Tests soon revealed that at least a 30% increase in output consistency to the deckers was possible, that tonnages up to 150 tons per day could be handled by a single unit with ease when driven by a 75-hp. motor, that tailings could readily be held at 5 to 6% thus obviating the need for rescreening, and that, on a 600-ton basis, approximately 500 horsepower could be saved in screening and in white water pumping.

Based on this performance, it was decided to remove the existing screens and replace them with six Cowan screens. It is possible to operate the mill with four screens, daily production being 600 tons of groundwood, but normally five screens are used due to the reduced possibility of screen plate breakage. At the same time, the original installation of 30 deckers has proved more than adequate for the higher tonnage due to increased consistency of the unthickened stock, whereas 26 to 28 deckers had been required for 480 tons. Only 23 or 24 are now necessary for thickening 600 tons daily.

Elimination of rescreening has vastly simplified the whole system while the reduction in reject volume to the refiner has allowed the mill to eliminate the refiner screen stage and thus get away entirely from the awkward problem of rescreening this stock efficiently. Stock from the bull screens goes to the Cowan screens. The accepted stock from these units is directed to the deckers while the rejects go to a refiner before being returned to the bull screen and back into the system.

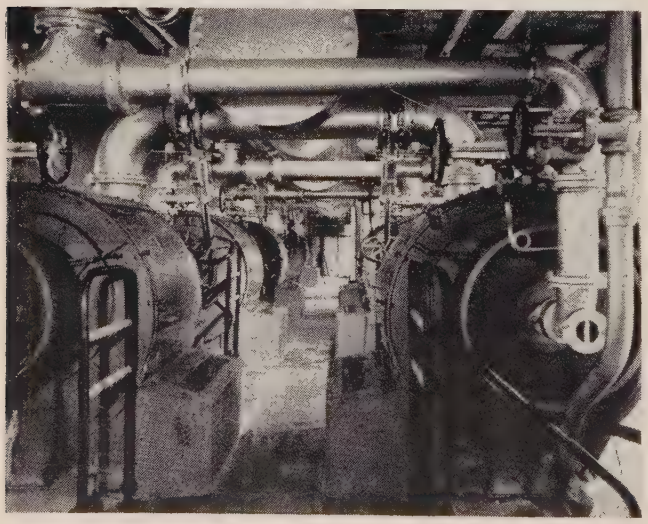

Fig. 3. Cowan Screen Installation at the Kenogami Mill

As to operating details, the screens are equipped with Lithcoted plates of 0.065-inch perforations on the inlet side of the baffle, and 0.055-inch on the tailings side. White water dilution is admitted under 3 to 5 pounds pressure, each screen shower line being equipped with individual gages. Over-all power requirements average 0.6 hp. days per ton.

Following the installation and successful operation of the Riverbend mill system, the screen room at the Kenogami mill was equipped with Cowan screens. Here also, increasing mill production had resulted in a screening and, in particular, a deckering bottleneck. All 36 deckers were required for thickening about 580 tons of groundwood daily, and no space was available for accommodating the additional units required for handling a proposed 700 tons. Seven Cowan screens were installed, six of which are normally in operation but only five of which are actually required to screen the 700 tons produced. At the same time 28 to 30 deckers are sufficient for thickening.

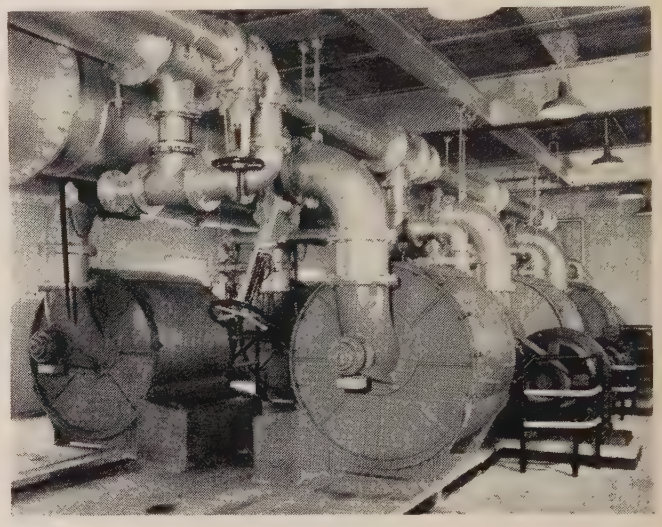

Fig. 4. Cowan Screen Installation at the Kenogami Mill

The system finally adopted is somewhat more complicated than that at the Riverbend mill due to the fact that the Kenogami mill has a board machine which takes varying quantities of groundwood rejects and refined rejects depending upon the grade of product being manufactured. It has been found necessary to provide a secondary screening stage, the accepted stock from which can be diverted to the board machine or alternatively to the groundwood deckers. At times, large quantities of secondary screen stock are in demand, and on these occasions Cowan screen rejects are deliberately increased: an effective method being the substitution of metal for Lithcote plates.

As at Riverbend mill, plates are graduated 0.065-inch and 0.055-inch perforations, and dilution water is held at about 3 to 5 pounds pressure. Over-all power requirements are just over 0.5 hp. days per ton.

Simplification of the screening systems at Kenogami and Riverbend mills, as outlined in the foregoing, has also resulted in a substantial reduction in screen room labor, so that the mill operators are highly pleased, in every respect, with the new installations.

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Douglas Fir Heartwood Flavanone

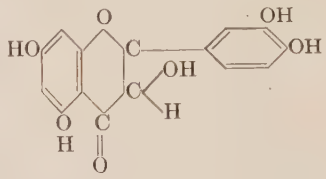
Its Properties and Influence on Sulphite Pulping

JOHN C. PEW

A new crystalline compound, the 3,3′,4′,5,7-pentahydroxyflavanone has been found in Douglas fir heartwood. Some properties of this compound and means of isolation are described. Small-scale sulphite pulping experiments were made using chips of unextracted and extracted Douglas fir heartwood, Douglas fir sapwood, spruce wood, spruce wood with the flavanone added to the cooking liquor, and spruce wood impregnated with the flavanone. The results indicate that the presence of the flavanone is an important factor in the sulphite pulping resistance of this species.

It has long been known that certain species of wood, notably the pines and Douglas fir (*Pseudotsuga taxifolia*), resist pulping by the sulphite process. It has been recognized in recent years (*1, 5*) that the heartwood alone pulped incompletely, whereas the sapwood behaved more or less normally. Early investigators believed that the resinous extractives (usually present in higher concentration in the heartwood than in the sapwood) interfered with the penetration of the pulping liquor into the wood chips and thus caused incomplete and nonuniform pulping. Fluorescence under ultraviolet light and certain staining reactions (*6*), however, suggested that chemical substances existing exclusively in the heartwood might be responsible for the pulping retardation, and work was begun on this subject at the Forest Products Laboratory. While work was in progress to isolate such substances from southern yellow pine, Erdtmann (*2*) announced that he had discovered the presence of phenolic compounds (a dihydroxystilbene and its monomethylether) in the heartwood of the European pine, *Pinus sylvestris*, and demonstrated that it could cause pulping retardation. In the work at the Laboratory no stilbene derivatives were found to be present in Douglas fir, but staining reactions by ferric chloride, uranium acetate, and potassium dichromate indicated the probable presence of phenolic substances in the heartwood of this species.

A colorless crystalline compound was isolated at the Forest Products Laboratory from the alcoholic extract of Douglas fir heartwood. It had a corrected melting point of 240 to 242°C. (dec.) and was optically active. It was found to be readily soluble in alcohols, acetone, and boiling water, somewhat soluble in ether and in cold water and insoluble in benzene. Aqueous solutions gave green to black colorations with ferric chloride. Alcoholic solutions produced a purple-red color on reduction with magnesium and hydrochloric acid suggesting a flavanone structure. Also air oxidation of hot dilute sulphuric acid solutions of the compound produced the yellow natural dyestuff quercetin. These and other reactions indicated the material to be a new flavanone, the 3,3′,4′,5,7-pentahydroxy derivative (I).



(I)

This flavanone is the fifth naturally occurring 3-hydroxyflavanone to be found since the first was discovered about 12 years ago (three of which were isolated from heartwoods). The identity of the Douglas fir flavanone was confirmed by synthesis.

The occurrence of 3-hydroxyflavanones in the heartwood of three species suggested that they might be present in others as well. Investigation of the South American wood coigue (*Nothofagus dombeyi* Blume), the heartwood of which was known to resist sulphite pulping, showed it to contain naringenin and the corresponding 3-hydroxyflavanone (3,4′,5,7-tetrahydroxyflavanone). Black cherry (*Prunus serotina* Ehrh) also contains these compounds.

The flavanone is readily extracted from the Douglas fir heartwood at room temperature with a variety of solvents, such as the alcohols, alcohol-benzene, and acetone, and also with hot water. Its separation from the other extractives, however, presents difficulties, the soluble ligninlike material present being particularly troublesome. One method used was to evaporate a solution of the extract onto sand and then leach the coated sand with water at room temperature. The resulting aqueous extract was extracted with ether, the ether distilled off, and the residue recrystallized from aqueous alcohol. In another method aqueous methyl alcohol was used as the extractant. This solvent rejected much of the ligneous material while effectively removing the flavanone.

The amount of flavanone present in Douglas fir heartwood varies with the type of wood. Because of the losses involved in isolation, the exact amount is difficult to determine but probably averages about 1%. In one sample of wood 2.2% of the crude compound was recovered.

PULPING STUDIES

Although the commercial pulping of Douglas fir is done by the alkaline processes, the resistance of the heartwood of this species (and of the pines) to sulphite digestion is of considerable theoretical interest. In the case of Douglas fir the Forest Products Laboratory has published (*1*) a summary of the work done on the practical possibilities of pulping this species, using liquors containing calcium base and other bases as

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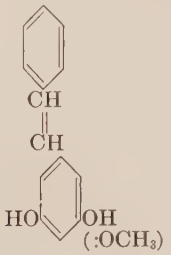
well. From the standpoint of the chemistry involved an important contribution is found in the work of Erdtmann (*2, 3*) who discovered that "pinosylvin" (II) and its methyl ether (III) occurred in Scotch pine



(II)

(III)

heartwood to the extent of about 0.8%. These naturally occurring phenolic compounds, as well as the simple polyhydroxyphenols were demonstrated to exert a definite inhibiting effect on sulphite pulping. Furthermore, he found (*4*) that spruce logs, ponded a long time with the bark on, developed a shell of resistant wood containing phenolic substances.

Method of Digestion

Pieces of wood $^1/_8$ by 1 by $^5/_8$ inch in the grain direction (except as when stated otherwise) were cut from second-growth Douglas fir and from spruce pulpwood. The chips were conditioned to 7% moisture content and stored in closed containers. In making a cook, chips equivalent to 40 grams dry weight were charged into a stainless steel calorimeter bomb of about 300 cubic centimeters capacity, and weighted down with a perforated plate. Then 200 cubic centimeters of cooking acid containing 5.7% total sulphur dioxide with 2.4% sulphur dioxide combined as calcium bisulphite were added. The bombs, after closing, were heated by immersion in a glycerin bath at 110°C. for 3.5 hours in order to insure complete penetration of the chips with the liquor and then at 140°C. for 4 hours to finish the digestion. The bombs were cooled under the tap; the liquor was drained off; and the chips were washed with water. The digested chips were fiberized by agitating them in water suspension with an electric stirrer under standardized conditions. The pulp suspension was screened on a small diaphragm screen and the yield of pulp and screenings determined. The permanganate numbers and lignin contents of the pulps were determined by standard TAPPI methods (*7*).

Digestion of spruce under the conditions described gave results that were to be expected in normal cooking. The yield was 47.4% and the pulp of good color and purity. Screenings were absent, and the spent acid contained 0.20% of sulphur dioxide combined as calcium bisulphite. With Douglas fir and with spruce cooks to which the flavanone had been added the spent cooking liquor assumed a deep orange color (even when greatly diluted) and the pulps and screenings were at first a bright yellow, becoming tan on standing in the moist condition. Also analysis of the spent liquor frequently revealed that the base had been entirely consumed, a negative value for combined sulphur dioxide being obtained.

Vacuum Impregnation with Cooking Liquor. In an experiment on vacuum impregnation with cooking liquor the chips were charged to a flask that would just contain them. The flask was evacuated and cold cooking liquor run in. After standing some time, the chips were drained and cooked as usual, adding enough liquor to the bomb to make a total content of 200 cc. In a separate trial it was found that at the end of the 110°C. impregnation period the vacuum-treated chips contained one-third more liquor than the Douglas-fir heartwood or spruce chips not evacuated.

Extraction of Chips. Douglas-fir heartwood chips (300 grams, 93% dry) were placed in a flask; the flask was evacuated; and 2 liters of methanol were run in. The chips were allowed to remain 6 weeks with occasional agitation and several changes of solvent. They were then drained and conditioned as originally (30% relative humidity) for a week; loss on extraction was 3.8%.

Vacuum Impregnation of Spruce with Flavanone and Catechin. In this procedure a hot aqueous solution of the flavanone in suitable concentration was placed in contact with the evacuated chips and allowed to stand. The liquor was then drained and the flavanone content computed by the gain in weight. The moist chips were allowed to stand a week in a closed container, then dried in air and conditioned at 30% relative humidity.

DISCUSSION

From the data in Table I it may be seen that Douglas fir sapwood (cook No. 1) containing only traces of flavanone and small amounts of resinous substances, pulped about as readily as spruce (cook No. 9). The heartwood (cook No. 2), however, gave a large amount of screenings and very impure pulp. The pulping of chips extracted with methanol, as in cook No. 3, though showing marked improvement over the results of cook No. 2, was still considerably retarded. This may be explained by the observation that even finely ground Douglas fir heartwood, when exhaustively extracted in a Soxhlet apparatus with a variety of organic solvents, still retained much of its original orange color and gave distinct ferric chloride and uranium acetate staining reactions. Thus it is indicated that the flavanone or associated compounds are not completely extractable by chemically inert solvents.

Vacuum impregnation (cook No. 4) aided digestion, though indicator tests proved that the 3.5-hour impregnation period used was sufficient for the cooking liquor to reach the center of the chips. In separate experiments the vacuum procedure was found to increase the amount of liquor in the chips at the end of the 110°C. impregnation period by about one-third. This placed more chemical in the interior of the chip (where it normally may become nearly exhausted), presumably promoting sulphonation at the expense of phenolization. Cutting the chips so as to give freer excess of the pulping liquor to the interior (cooks Nos. 5 and 7) gave marked improvement, and this modification coupled with extraction (cooks Nos. 6 and 8) resulted in almost normal pulping.

With spruce wood, addition to the cooking liquor of such highly reactive phenols as phloroglucinol (cook No. 15) caused extreme retardation of the pulping reaction. Resorcinol (cook No. 16) was less effective and catechol (cook No. 17) nearly without action.

Table I. Sulphite Pulping Experiments

Cook No.	Description of Cook	Screenings, %	Permanganate Number of Pulp	Lignin in Pulp, %
	Douglas fir			
1	Sapwood	0.2	12	2.4
2	Heartwood	21.8	>35	11.1
3	Heartwood extracted with MeOH	5.0	28	5.9
4	Heartwood—vacuum impregnation with cooking liquor	1.6	>35	8.5
5	Heartwood—1/8-inch dimension in fiber direction	4.2	30	7.6
6	Heartwood—1/8-inch dimension in fiber direction—MeOH extracted	0.1	15	....
7	Heartwood—thickness reduced to 1/16 inch	6.0	>35	8.1
8	Heartwood—MeOH extracted—thickness reduced to 1/16 inch	0.2	18	4.4
	Spruce			
9	Untreated	0.0	13	1.8
10	0.9%[a] Douglas fir flavanone added to cooking liquor	0.1	18	3.2
11	1.7% flavanone added to cooking liquor	0.2	22	4.2
12	Wood impregnated with 1.7% flavanone	0.8	33	6.4
13	4.4% flavanone added to cooking liquor	0.2	30	5.5
14	Wood impregnated with 4.4% flavanone	5.9	>35	14.1
15	0.7%[b] phloroglucinol added to cooking liquor	22.3	>35	10.5
16	0.6%[b] resorcinol added to cooking liquor	2.2	35	9.0
17	0.6%[b] catechol added to cooking liquor	0.1	17	2.9
18	1.7%[b] d-catechin added to cooking liquor	0.3	25	5.7
19	Wood impregnated with 1.7[b] catechin	4.1	>35	11.8

[a] In all cases amount of chemical was based on dry wood charged.
[b] Amount used approximately the molecular equivalent to the 1.7% flavanone.

The flavanone and cathechin (cooks Nos. 10, 11, 13, and 18) were only mildly reactive; 4.4% of the flavanone (much more than is naturally present in the Douglas fir heartwood) was necessary to produce markedly impure pulp. When these phenolic substances were impregnated into the chips before digestion (cooks Nos. 12, 14, and 19) they produced considerably greater retarding effect.

Though it is apparent that the phenols are important in the sulphite pulping resistance of Douglas fir heartwood, the total effect appears to be the result of several interrelated factors that are difficult to separate. From the data obtained and from the observations of Erdtmann and others, however, a reasonable explanation of the pulping resistance of this species may be formulated. From the standpoint of pulping behavior the extraneous matter in the heartwood may be classified as follows: (1) phenolic compounds (chiefly polyhydroxyflavanone) soluble in organic solvents; (2) nonextractable phenolic substances; (3) nonphenolic extractives, largely resinous; and (4) deposits (insoluble in organic solvents) which lend impermeability to the wood. When an attempt is made to pulp this heartwood the penetration of cooking liquor is retarded by the extractable and nonextractable extraneous substances. Even if penetrated, the low permeability lessens the diffusion of chemical into the interior of the chips and the lignosulphuric acid out, thus retarding the sulphonation reaction. The phenols present tend to condense with the lignin to form substances insoluble in the cooking liquor, a reaction in direct competition with normal sulphonation. The speed of this reaction is controlled by such factors as the temperature, the hydrogen-ion concentration, and the concentration of the phenols. These phenols, although not especially reactive toward lignin in dilute solution (in comparison with such phenols as phloroglucinol and resorcinol), are concentrated in the zone of reaction; that is, in the wood tissue, the low permeability of the wood tending to retard their extraction and dilution. Furthermore, the phenols and other extraneous matters in themselves or in consequence of their pulping retardation promote decomposition of the cooking liquor, which, in turn, causes further retarding effect. The net result is much unpulped wood (screenings) and impure pulps.

Pulping is favored by conditions that promote sulphonation or retard phenolization of the lignin. Vacuum impregnation and high sulphur dioxide concentration of the liquor (*1*) aid sulphonation by supplying more chemical in the reaction zone. Short chips, thin chips, and sawdust give better pulping because the high impermeability of the wood is in part offset, improving diffusion of chemical into the central portion of the chips and of lignosulphonic acid and phenols out of this region. Better pulping at low temperatures is obtained (*1*) because phenolization and sulphonization reactions have different temperature coefficients (*3*), the sulphonization reaction being favored.

To summarize, Douglas fir (and pine) heartwood resists sulphite pulping because it contains phenolic substances and because it has low permeability. The phenols tend to form insoluble phenol-lignin compounds. The low permeability retards penetration and restricts normal diffusion of chemical substances in and out of the chips and also tends to maintain the soluble phenols at high concentration (and therefore at a high degree of effectiveness) in the interior of the chips. Associated with these effects is the decomposition of the cooking liquor, which, in turn, causes further pulping retardation.

Apparently, Douglas fir heartwood reacts more or less normally toward sulphate pulping,[1] although the phenolic substances were found to react with lignin in alkaline as well as acid solutions (*3*). The fact that the flavanone may be changed to a variety of highly colored substances suggests, however, that the high bleach requirement of Douglas fir sulphate pulps may, in part at least, arise from this source.

[1] An instance was observed at the Laboratory in which a sample of the heartwood markedly resisted soda pulping.

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Instrumentation of the Groundwood Pulping Process

J. N. FRANKLIN

In discussing instrumentation the whole process must be considered and each step analyzed.

In the groundwood pulping process, uniformity from start to finish is required. Instrumentation should give as precise a picture as possible of the achievement of such uniformity and serve to control wherever possible.

First consideration is given to the operator. Upon the ease with which he can measure and the speed with which he can react to correct faulty measurement depends the success of the whole venture.

This paper attempts to show present, and possible future, uses of instrumentation at each step of the process. It points out what must be accomplished by such instrumentation in order that this equipment be not just justifiable but strictly essential to efficient operation.

The groundwood pulping process is assumed to include all functions from log pond to machine.

THIS paper will attempt to analyze the pulpmakers daily problem and show where presently available instrumentation can be of service to him in his work and also where he is hampered by the lack of suitable measuring and controlling devices. In other words the objective of uniformity of every step in the process of pulp manufacture and treatment will be considered with the question always in mind: how best can instrumentation be of service and what further developments are necessary before the pulpmaker can be given the very last of the measuring and control devices he needs.

Nothing new will be presented though it is possible that the approach may be novel to some as it is not always that the over-all needs of the process and of the men responsible for operation are considered when new instrument equipment is applied.

THE MEASUREMENT OF PULP QUALITY

It will surely be contended by some, and they may very well be right, that the measurement of pulp quality is so difficult that the making of pulp will forever remain an art controlled mainly by the inspection of the blue grass and the skill of the stone sharpener.

To such a premise it is contended that it is the purpose of instrumentation to assist these men in their inspections and their skills, to make the inspections continuous and recordable rather than dependent upon spot samples, and to try in every way possible and with every means to correlate the observation and skills of one man with those of another and of one group with another group. It must be readily agreed that no two men will have identical reactions to any one observation and when such personal discrepancies are multiplied by the number of responsible men in a mill and by the number of mills in the industry it is easy to see the potential lack of uniformity which exists.

It has always been the writer's contention that the operator who is provided with instrumentation has to be a better operator than the man who relies on his own observations. Here is the reason for this contention. The man with instruments has many more landmarks to guide him. These are useless to him unless he can read them correctly and interpret them. When he can do this he is certainly able to steer a much straighter course at each step in the process toward uniform pulp to the machines than is his brother who is limited to one or two landmarks. He must, therefore, be skilled in correlation of lines on charts with conditions in the process in addition to being as skilled as his brother in operating without such charts. The reason for this last statement, often overlooked, is that instruments, like all other mechanical equipment, can and will go wrong. It is of vital importance for the enlightened operator to be aware of this fact and be prepared for it. He should be able to recognize an instrument that is not telling the truth and be able to compensate for the error until he can get it repaired. This is particularly true of controllers.

Thus it is that instruments, far from relieving the operator of responsibility, actually increase the demands upon his intelligence. While they may save him considerable time, many steps, and make his work more enjoyable, they will never relieve him of his responsibility for producing good pulp.

SECTION I: EQUIPMENT AND ITS FUNCTION

It has been thought advisable to divide the paper into two sections. The first section will examine the process and suggest what is required. The second will give details of the existing instrumentation equipment as well as sketch the developments required.

So many of the difficulties encountered in the groundwood mill are credited to the wood supply that it would be useful to weigh the wood and obtain its moisture and density as well as to know the actual amount of wood ground in each grinder unit. The question of weight is relatively simple though normally a rather expensive installation is necessary.

When wood is delivered by truck and railway as well as by water the problem is of course much more involved and when it is further divided, after barking, to the groundwood, sulphite, and storage sections it is increasingly difficult. The difficulty generally arises through lack of either space or money or both as the actual measurement devices are well known. It is well to ponder the fact that methods used to estimate wood deliveries, in contrast to precise measurements, can usually be shown to contain errors of ± 5 to $\pm 10\%$ or even higher. This is purely an accounting

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and yield problems and accountants are usually insistent upon much closer measurements of deliveries. It is well to keep in mind the fundamental difference between the three unrelated processes of counting, measuring, and estimating.

Continuous moisture and density determinations are by no means so easy though equally important in accounting and operation to the measurement of volume and weight.

The wood supplied to each unit or grinder is much more important from the point of view of the pulpmaker. It gives him his grinding rate by shifts or from hour to hour if he wants to read it for any special work.

GRINDER OPERATION

In general the large grinders at present in use consist of the continuous, the hydraulic or pressure foot, and the Roberts types.

In the interest of uniform stock quality it is necessary to apply the wood to the stones in such a way that the action of the stone on the wood, regardless of the wood species, produces a fiber of uniform quality.

It is well known that groundwood pulp is a mixture of long fibers and short fibers, free stock and slow stock. Any standard measurement which is set can only be approached from either side. For instance, a standard freeness of 150 might be set for a composite stock from say 30 stones. It is conceivable that if each individual stone was tested 15 might be giving 100 freeness stock and 15 giving 200 freeness stock. The mixture would, conceivably, be giving the desired freeness. A much better stock would have variations or deviation from the standard of only 10 points. Thus, no individual grinder would give below 140 and none above 160.

The point to be made is that, in all uniformity studies, the deviation from the standard is usually of far greater importance than the average and all work should attempt to have the deviation as close to zero as possible.

Now it will probably be argued with considerable vehemence and considerable truth that, because it is impossible to make a uniform stock on all grinders, a wide deviation is a safety measure so that any serious rise or fall of the average can be quickly remedied by severe treatment on one stone.

It is the contention of those interested in instrumentation that it should be possible to measure values sufficiently easily and accurately from each individual grinder that wide variations of the whole would be impossible, and that any serious variation in an individual grinder would be picked up and remedied in the shortest possible time.

This must be considered to be the aim though not yet an accomplished fact.

Grinder control involves four separate though related functions: (1) motor load control; (2) control of wood pressure on the stone; (3) control of pulp temperature which involves also temperature, pressure, consistency, and flow control on the water which is used on grinder showers; and (4) the whole question of the control of stone treatment.

Motor Load Control

In considering the hydraulic type of grinder an interesting problem develops when the number of times per day that pockets are filled are considered. In a line of grinders with four pockets on two stones similar stock conditions cannot prevail when three pockets are being used to load the motor to the same load value (as controlled by the load controller) whenever one pocket is being refilled. Thus there is one sample of a variation in operation being used to compensate and correct a load change on a motor when, from a purely pulpmaking standpoint, the reverse should be true. The same argument applies more or less to the other types of grinders, and while it is an interesting problem it is a very difficult one to overcome because it is well known that, especially with the small power plants in use at some of the remote paper mills, large power swings cannot be tolerated. Therefore pulp quality must take second place to power house operation: a bad situation from the point of view of stock quality.

Control of Wood Pressure on the Stone

Again, considering the hydraulic type of grinder, it would not be very difficult, from a purely control angle, to maintain constant pressure in the rams of the individual pressure foots while backing one off for reloading or during uniform operation when wood species or hardness, and therefore grinding rate, changed. This is not necessarily offered as a solution first because it would probably be impossible to govern a power station under such conditions and secondly because constant pressure, when exerted on knots, etc., may be little better than constant load. It is merely meant to promote discussion among the experts in the pulp field and the experts in the control field of which the writer is obviously neither.

The present-day control systems, such as are used in the continuous and Roberts type grinders, may be adequate to provide a stock of sufficiently uniform characteristics that it can be fabricated into a sheet of newsprint but it would be very interesting to know just how good a sheet the papermakers could make if the fine, coarse, and medium aggregates were provided in the best possible manner and ratios.

Control of Pulp Temperature

It is well for the pulpmaker to realize that the amount of heat he furnishes to the stock in the grinding process and the efficiency with which that heat is subsequently conserved governs to a very great extent the formation of the sheet on the wire, its drainage, as well as the growth of slime-forming microorganisms in the whole pulp system.

Heat available at the grinder pits is controlled partly by the heat of grinding or loading of the wood on the stone and partly by the heat content of the stone shower water and subsequent dilution waters. The first factor, heat of grinding, depends on stone surface, pressure, and horsepower per ton required. This in turn concerns the wood species, amount of regrinding, etc. Thus, from the instrumentation point of view, the motor load controller and the grinder pit temperature controller are important.

The effectiveness of the grinder pit temperature controller in assisting to provide uniform stock has frequently been questioned. There is no doubt that grinder pit consistency has as much if not more influence on stock uniformity as has temperature. The control of temperature, however, has been in many cases the easiest way of putting one variable on a chart and as such has been another landmark to guide the pulpmaker. It has been suggested that the index of the temperature controller should be adjusted from time to time in order to maintain pit consistency at a reasonably constant value.

As far as instruments are concerned it should not be too difficult to install a consistency "pickup" in the grinder pit, take it outside by means of, say, a torque tube, convert it to an air pressure and reset, automatically, the index on the temperature controller by variations in consistency.

It is sometimes found that such controllers as the grinder temperature controller are installed using white water for dilution without sufficient attention being paid to the characteristics of this dilution medium. Obviously the temperature, pressure, and consistency of this water will have a marked bearing on the results obtained from such controls. It is quite impossible to effect good temperature control by using a dilution medium which itself has wide variations in temperature and whose flow through the controlling valve is limited one minute by lack of adequate pressure though flushed by a pressure increase the next. Uniformity must therefore go right back to the begining in each case.

Such an arrangement would leave only freeness, classification, and fiber length of the present known measurable variables with which to deal. Continuous measurements of these three variables are difficult. No doubt, in the near future, a satisfactory continuous freeness machine will be developed. When this is available it will merely be necessary to reset the motor load controller by the freeness variations to obtain a reasonably constant stock freeness, assuming a sound stone treatment program.

The Control of Stone Treatment

For uniform or well mixed, well seasoned wood with controlled wood-to-stone pressure it is necessary that the stone surface should be as uniform as possible. This is a field which has interested the instrument men for some years with scant success as they have, so far, been unable to give the pulpmaker and particularly the stonesharpener much assistance in the way of landmarks to guide him.

The stone makers are producing a much more uniform stone than it was possible to obtain some years ago. This is a great advance but it would still be more useful if the wearing effect of the wood on the stone could be measured and, when the time came for treatment, it be known that such treatment was applied uniformly across the face of the stone and at the correct pressure to ensure the desired imprint. This latter measurement may not be too far away.

PULP DILUTION AND SCREENING

Pulp, therefore, flows from the individual grinders in as uniform condition as it can possibly be made. It is still a compromise of fairly wide extremes; contains many unground knots, nugs, and long shives and slivers; and must be conveyed, usually without the aid of pumps because of the size of the unground material, to the coarse screens. Such material is allowed to flow to the coarse screens although operators are fully aware that these screens operate at their best efficiency when supplied with stock of uniform flow and of uniform consistency.

In the groundwood pulp mill, therefore, it is uniformity of the stock which enters and leaves the grinder canal which governs the ease of operation and ultimate uniformity of the product.

In order to furnish the coarse screens with stock of a constant consistency and at a constant volume it is necessary to first add the correct amount of dilution water to insure correct and uniform consistency and then to regulate the flow of this mixture to the coarse screens.

The first step is relatively easy and is done in several mills by measuring the consistency of the coarse screen effluent (this is the stock free of heavy material which would plug most controllers) and controlling the dilution water valve from this point. This assumes that the amount of rejects from the screens is reasonably constant and that therefore the consistency measurement after the screen is a fairly accurate representation of the consistency before the screen. To be certain of eliminating this added variable some attempts have been made with considerable success to measure the consistency entering the screen. This is done with a device which either rejects the knots or allows them to pass over or through without interference. The sampling possibilities and head available on this gravity part of the system usually dictate the method used.

The control of volume to the coarse screens is a more difficult problem. In order to control volume or flow adequately in any process it is necessary to have capacity back of the controlling means. Due to the heavy materials present in the stock leaving the grinders it is usually impractical to pump it, and therefore little or no capacity is provided between the grinders and the coarse screens. Nor is there usually any available head to permit even a small pressure drop across a controlling means. Where the grinder canal is deep and wide and would permit a certain amount of variation in level it is a relatively simple problem to maintain a constant level in the coarse screen pit by a self-cleaning, damper type valve at the entrance to the screens actuated by a standard level controller in the coarse screen pit.

Such a level controller operates also to maintain a constant suction head on the screen discharge pumps thus gaining uniformity of supply and discharge. Again, however, no capacity is usually provided between the coarse and the fine screens. Some may be gained by setting the level controller in the coarse screen pit on a wide range so that the greatest capacity is utilized without the pumps losing suction or the screens overflowing. This is a simple matter on the present-day instruments.

Such utilization of all available capacity permits the use of another level controller on the fine screen feed flume which keeps the head on the fine screen

feed constant for any operating conditions. Such a controller has the added advantage of eliminating the overflow line from the fine screen header back to the coarse screens.

ELIMINATION OF OVERFLOW

This latter consideration is one of the most important contributions of instrumentation. It is frequently if not always overlooked. With properly applied controls it is possible to have a straight-through system with no overflows whatever. The importance of this fact will be immediately apparent on consideration of: (1) the power required to pump the run-around, and (2) the relative cleanliness of a pressure and gravity line. It is always the gravity overflow lines which are the sources of dirt and of slime growth. This is particularly true of mills with a bad slime problem as the temperature in these lines is usually sufficiently lower than the main system to promote slime growth. (3) That, in new installations, it is sometimes possible to save the entire cost of the instruments and controls by eliminating the material and installation costs of large overflow lines.

The above considerations are so important that it is felt that they should be repeated at each step where control *vs.* overflow is discussed. For brevity, of course, this will not be done.

SCREENING

The customer is forever complaining about dirt in the sheet, and, of course, the customer is always right or at least he probably will be again in a very few years, possibly months.

Thus it is that anything that will improve screening will decrease dirt and will keep customers happy. Uniformity of feed flow under constant pressure is one sure way to improve screen performance. The flow of stock to the screen is not difficult to measure but the devices used require room, and space here is usually at a premium. The level controller already described will keep a constant pressure or head on the screen. Screen performance can then be gaged by a flow measurement of feed, tailings, and possibly accepted stock though one of these may well be computed by difference. The venturi flume with level recorder or the more expensive but more accurate and versatile area meter are adaptable to this service.

When considering screening the extraordinary influence of the screen shower on pulp cleanliness and quality should never be overlooked. The efficacy of a shower depends largely on the temperature, pressure, flow, and consistency of the water supplied to the shower. Some or all of these can be controlled to individual screens or to groups as arrangement, economy, and results dictate.

This question of water pressure, not only for screens, but for all pulp mill, paper mill, and contributing operations is so important that new designs might well call for sufficiently higher head pumps so that some pressure control system can be provided for individual services or for whole areas. Standards of pressure, set to conform to best operating practice and maintained within the limits possible with a modern controller, will pay handsome dividends in sheet cleanliness and over-all uniformity.

Control of the thickening process in which the pulp is prepared for storage, consistency control, and proportioning to other components of the furnish is a relatively simple matter. Here again, however, uniformity demands close attention to vat level, filtrate outflow, and wire condition. The first two can be recorded easily though the type of filter or decker used will govern the necessity and value of instrumentation. Certain it is, however, that at this point the operator has the best opportunity to mar an otherwise perfect blend of pulp by errors in judgment of how much unthickened stock to bypass. The more landmarks that can be given to him the closer he will come to supplying the machines and the storage reserves with pulp uniform in consistency, freeness, and temperature. After all one of the best indications of freeness is a well cleaned wire on a decker operating under constant feed conditions. If the level in the vat is controlled the output air pressure of the controller can be calibrated in freeness; or if the level is allowed to vary a record of it can be used as a picture of freeness.

STORAGE, CONSISTENCY CONTROL, AND PROPORTIONING

From the point of view of uniformity the storing of pulps, particularly in the less modern mills, has possibly a greater effect than any other single factor. The power that is saved by straight through flow using level control could be expended on agitation, circulation, and blending to great advantage. Certain it is that the intimate blending of stored pulps in the largest quantity possible carried on the uniformity program and allows stock to be fed to the consistency controllers of such a uniform quality that these controllers have little or no work to do. This is as it should be and ensures that the subsequent consistency control, either single or dual if necessary, will be enabled to take out the last bit of weight variation. Control of basis weight on the machines reflects this function to a very great extent.

As the work required of the consistency controller becomes less and less by virtue of the increased emphasis on uniformity in previous sections of the mill so the controller dilution water becomes more important than ever. In one case where a controller of this type was tried on the mixed stock to a news machine using a small percentage of filler it was found that the variation in the filler retention in the white water changed the final basis weight sufficiently to warrant removing the controller entirely. (Control of mixed stock incidentally is far more difficult than control of components.) It must therefore be stressed that water of uniform consistency, temperature, and pressure is necessary for good consistency control. It appears also to be far better to have low pressure water and large valves than the reverse though the original cost of the valves may be considerably greater.

Finally, the second stage consistency controller feeds the stock proportioner, either of the conventional paddle wheel type or the more modern area meter type, before entering the mixed stock chest. A level controller on the mixed stock chest resetting the flow through the master proportioner keeps the head on the pump to the machines constant so that constant supply

of uniform stock to the machines is assured at all times.

AUXILIARIES

Of course the man in charge of operations will be assisted greatly if all recorders and controllers are assembled in one place so that he can examine the whole recordable unit under his control without moving more than the length of the panel board.

Of great convenience are level recorders on all tanks with red and blue prominent lines (or suitably marked lucite sectors) showing the range of the most satisfactory operating levels as well as the overflow level for each tank.

Where some materials are conveyed out of the system, either to refiners or to sewer, parshall flumes with suitably marked level recorders furnish a complete picture of otherwise uncontrolled outflows.

The actual instruments involved in this discussion together with alternate layouts and limitations will be discussed in Section II of this paper which will be presented as an appendix for reference rather than enter the present discussion. The reasons for instrumentation and its operational value and implications are far more interesting and leave far more scope for discussion than does a catalog of instrument specifications.

SECTION II: EXISTING INSTRUMENTATION AND REQUIRED DEVELOPMENT

Wood Measuring Devices (Wood, volume, number of sticks, etc.)

Weightometers. Continuous weighing machines of various makes are available which can be adapted to weighing wood on conveyors going to any section of the mill. When the total weight is determined, however, the problem of moisture and density still remains.

Volume Measurement. The measurement of wood by volume is well covered in the experiments and developments made at the Ontario Paper Company.

Area Integrators. The use of electronic devices to indicate the solid area of the wood piled on flat cars or tiered at the pile is useful when all wood going to the mill is so handled but is of no value for loosely piled wood.

Log Counters. Electronic counters which record each stick as it passes over a conveyor are being developed.

Wood Moisture

The all important factor of wood moisture has not yet been the subject of sufficient study to obtain a record and mills are still dependent on moisture determinations on more or less representative samples.

Wood Density

The same remarks apply to wood density though the experiments of the Ontario Paper Company tend to compensate for this figure.

The Measurement of Wood to Individual Grinders

The standard method in general use employs a chain or a circular toothed saw. When these are calibrated against the average run of wood to the mill a fair result of the wood delivered to each grinder can be obtained. If, however, the size of wood varies materially, the hour-to-hour and day-to-day results will be subject to more or less error.

Recording Equipment. Any amount of elaborate equipment could be installed on the individual grinders, such as individual weightometers, but the cost of such installations is prohibitive and except in unusual circumstances or in test runs cannot possibly be justified.

Grinder Operation

(For an excellent treatise on averages and deviations see the paper presented under the auspices of the Process Instrumentation Committee, C.P.P.A., January, 1948 by Charles Bicking.)

Motor Load Control. The maintenance of constant load by a load controller is a simple control problem. It has been thrust upon the groundwood people by the power people and is contrary to all principles of good stock control. The solution of this problem requires close cooperation between and study by the grinder builders, the power equipment manufacturers, and the instrument and control people as well as the pulpmaker. It must be solved before the latter has good control over the quality and uniformity of his product.

Control of Wood Pressure on the Stone. Here is an example of a control actuated by something other than the desired value: an anachronism. In all pressure control problems the desired pressure must be known, thus be measurable and be measurable continuously. Then and only then can a corrective means be actuated by the measuring means until the value of the measuring means is a constant or nearly so.

Think of any pressure controller on steam or water (or anything else) and this will be apparent, *but* it is desired to control the pressure of the wood on the stone without measuring that pressure! This pressure is not measured and used as a control, but something entirely different, motor load, is determined and applied as a control. That it is entirely different is much more evident in the four-pocket, two-stone grinder line than in any other, but the fallacy exists on all types though the Roberts tends to overcome it.

Control of Pulp Temperature. The standard pulp temperature controller is well known. It consists of a temperature responsive bulb specially designed to give an average temperature across its 4-foot span, to transmit this to a conventional temperature controller which in turn controls the flow of white water to the grinder showers by means of a conventional control valve. The mechanism is simple; its value in papermaking questioned by many. It undoubtedly tends to iron out one variable; to get something under control: this is of prime value but if in doing so it upsets other relationships some further study is necessary.

The temperature which is important is the actual grinding temperature, the temperature at the point of contact of wood and stone. The best means available of approaching this value is the present controller. It is not the ultimate and progress must be made.

Pulp Consistency. Of far greater importance, say

some well-informed operators, than constant temperature at the point now measured (note that it is the point of measurement that is questioned not the value of temperature control *per se*) is constant consistency.

In the drive for uniformity it would seem probable that, ultimately, pulp will be emitted from the grinder pit at constant temperature, constant consistency, and constant freeness. That will be the day! But instrumentation people cannot rest complacently until it is achieved.

As a step toward control of consistency thought should probably be directed back to the days when beater operators in the fine paper industry used counterweighted bars immersed in their stock to indicate by their position when the stock within a beater was of the same consistency as the last beater dropped. This principle of measuring the height of a float in a stream of stock is used now on some designs of consistency controllers. There seems little reason to believe that, if the float or floats are shaped correctly to prevent hang up of shives, a satisfactory controller cannot be produced. By satisfactory is meant one that will control within fairly wide limits, say 3 ± 0.20%. This device would be used to reset the index pointer of the temperature controller.

Dilution Water Control. It is unreasonable to expect any controller to operate satisfactorily unless the controlling medium is itself uniform. This statement should be considered extremely carefully as the author has good reason to believe that it is scarcely considered at all in average paper mill control practice. It is fundamental, however, with the grinder temperature controller. At, say, 180°F. the controller positions the valve at mid position. With 50 p.s.i. white water upstream of the valve the flow may be 100 g.p.m. Now someone may want to hose down a bull screen or dilute the stock canal and opens a 4-inch hose from the valve supply header. The pressure is reduced to 25 p.s.i. causing a resultant flow through the half open valve of 70 g.p.m. and causing the temperature to rise. Corrective action from the controller opens the valve wide and by this time the man with the hose has shut it off. The 50 p.s.i. upstream of a wide open valve calls for drastic corrective action, and the system is in an unbalanced cycle. Pressure and temperature control is relatively simple to obtain with conventional instruments correctly applied.

Freeness Control. Freeness control is by no means simple. The problem of continuous measurement of freeness from each individual grinder pit must be solved before control is possible. Once such a measurement is a practical reality it will be a simple matter to reset the control which keeps a constant pressure of wood to stone.

Thus, to produce uniform groundwood a constant flow of uniform wood at constant pressure against a constant speed stone of uniform and maintained surface characteristics is required. When the density of the wood changes as shown by the resulting freeness more or less pressure must be applied at the wood-stone interface so that stock characteristics remain uniform. Any attempt to control the input to the grinder motor by variations in this wood-stone pressure should be sedulously avoided in the interests of good uniform quality pulp.

How to obtain these results? The first necessity is a consistency controller resetting the temperature controller. This provides pulp delivery from each grinder at uniform consistency and moderately uniform temperature, at least within known and controllable limits. With uniform consistency pulp it is not too difficult to measure quite accurately the pulp freeness with the present designs of decker-type measuring devices. It will probably be necessary to eliminate slivers before such a measurement but even this refinement may not be necessary.

Once such a freeness measurement is possible it merely remains to reset a pressure controller from it. This pressure controller maintains constant pressure of wood on stone. In the hydraulic-type grinder it is actuated by the water pressure on the pressure foot (note again that this must not be used to stabilize the input power to the motor); in the continuous-type grinder it is produced by the pull of the chains on the wood; and in the ring type grinder by the speed of the feed ring.

Stone Treatment Control. It should be quite possible to adapt the principle of press roll loading to furnish the stone-sharpener with a known, and recorded, pressure of his burr on the stone. This device would measure the pressure now exerted in the mandril and does involve the same limitations that apply to the press loading control. All linkages and rubbing surfaces must be maintained at a zero or uniform friction effect. The stone sharpener should be able to produce, for each treatment, a chart similar to a steam engine indicator diagram showing: (1) the pressure, (2) the time, and (3) the position of the burr on the stone at any given time. It is believed that all components of such a device are now available.

Screening Control

Control at the coarse screens involves level control of the screen pit, which is simple and conventional, and also thin stock consistency control.

The control of thin stock (0.5 to 1%) is not simple nor conventional. It is accomplished in a number of ways still in the development and experience stage. The major difficulty here is to isolate the consistency and freeness functions. With either one constant it is not difficult to measure the other but with both varying it is next to impossible to call a drainage rate of the stock anything but a "stock characteristic" and let it go at that. However, with relatively constant freeness the regulators which work on the "decker" principle are quite satisfactory.

The scanning of the pulp stream by one or more photoelectric cells is used for a consistency measurement and control. This is the only one at present that attempts to eliminate freeness effects and is reported satisfactory though admittedly it requires considerable attention and frequent calibration.

The float types are offered though their sensitivity must leave a great deal to be desired, because this type, while used on thick stock (2 to 4%) for many years, were never noted for intrinsic accuracy though they did have much to commend them.

On the satisfactory solution of this stock regulation hinges the simplicity of the newsprint industry. With

an efficient regulator there is little reason to believe that stock cannot flow directly from the screens to the paper machines without deckers, etc., thus cutting out entirely at least one of the "thick-thin" stages in manufacture. The advantages of such a system are many, and its acceptance will be all the more rapid if controls are such that uniformity is achieved at the beginning of the pulping process.

Thick Stock Consistency Control

While there are many simple recorders and controllers the one around which there is considerable controversy is the thick stock consistency control. It is very right and proper that this device should be the center of so much attention because upon its operation depends the basis weight of the sheet produced and hence the all-important customer satisfaction.

There are two major divisions of controllers: (1) the viscosity type, and (2) the torque type.

The viscosity type uses the change in viscosity of pulp flowing through a curved or a restricted straight path to actuate the controlled valve either by a standard level controller or by a direct float controlled mechanism.

The torque type uses the change in resistance to turning produced by variations in consistency to position a balanced motor and so a controlled valve.

Whatever the method the following are essential to good consistency control:

Good Sampling. No measurement is any better than the sample. Those devices which use the total flow of stock may have considerable advantage from this point of view. A study of a slide rule type calculator recently put out by a well-known equipment manufacturer will show that the friction losses in pipes leading to regulators vary very materially when consistencies vary from, say, $2\,^1/_2$ to $3\,^1/_2\%$. Thus, without proper sampling design the attendent piping may respond to a greater extent than the measuring device.

Viscosity vs. Freeness vs. Temperature Appreciation. With the viscosity-type consistency control freeness and temperature must be kept within close limits to avoid errors.

Elimination of extraneous effects such as cleaning sprays and anything else which will change to even a slight degree the sample as it flows through the various components of the meter.

Ease of valve operation is especially essential to good consistency control. The valve must be of the correct design to furnish the dilution water as required and must also be actuated by a sensitive controller equipped with sufficient responses to allow it to be "tuned" to the process accurately.

Thorough mixing of dilution water for obvious reasons though not always provided.

Ample and frequent checking by competent men both as to the mechanical functioning of the instrument and the testing of resultant pulp. It should be possible to produce a consistency controller with far less "error" than exists in the technique of sampling and testing a laboratory sample.

Proportioning and Machine Chest Level Control

The conventional displacement (or paddle) type proportioner is well known. The use of the area meter principle coupled to one or more ratio controllers is a relatively new development which shows considerable promise. Not the least of its virtues is that of requiring no overflow. (It might be stressed here that ultimate control of any process demands straight-through operation with no returns, no overflows, and no hold-up in large tanks.) This solution to the problem illustrates the use of standard flow meters in interesting ways and opens up a whole new field of thought.

The resetting of the paddle-type or the area meter-type proportioner from the level in the machine chest or by the demand of the machine uses conventional equipment.

Auxiliaries

There is much interesting auxiliary equipment in use in pulp mills.

Parshall Flumes. While only an adaptation of the conventional flow meter, the open channel venturi flume is a simple and effective device for measuring rejects, either stock or white water, from any part of the system. Records can be transmitted to the operator's location so that his work is simplified considerably.

Saunders Valves. The Saunders-type valve is particularly suited for use on pulp. It can easily be made "controlling" by the installation of the conventional diaphragm operated superstructure.

Butterfly Valves, while not new, are being introduced into the pulp mills with the area-type proportioner and may find many uses elsewhere. They also can be controlled from an instrument or remotely operated by hand.

Stock Valves. Automatic water dilution valves are now equipped with water purges to keep accumulations of slime-forming stock to a minimum. Hand gate valves are now designed with sealing apron which does away with the bonnetted gate valves which always collect decaying stocks contributing to heavy slime build-ups at some season of the year.

Panel Boards. With the present availability of transmitting equipment, advantage is being taken of the centralized panel board. Such a panel permits the operator to check his whole system without moving far away. Such boards add to the appearance of even the most dingy room as well as winning instant approval from the foreman whose movements are reduced. Much more use of remote hand-control valves is justified in a large mill even if metering equipment is kept to a minimum.

It is rather easy to indicate what should be done to make a process efficient and its product uniform. It is another matter to produce the process so controlled. There is, however, nothing radically new in the above approach, and none of the problems are insurmountable. They must all be solved before the extra quality newsprint which everyone is talking about will become an actual reality.

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TAPPI DIVISIONS AND COMMITTEES

Recent Reports of Activities

Report of the Executive Committee

Following is a report of the most recent meeting of the Executive Committee of the Technical Association of the Pulp and Paper Industry. It was held for publication in this issue of *Tappi* because most of the conclusions relate to activities of 1949.

The problems relating to the establishment of the new magazine required the first of the two days of the meeting. The following decisions regarding publication policy were reached.

EDITORIAL POLICIES

1. A committee of five was established to deal with policy matters relating to the new magazine. The Vice-President of the Association is to act as chairman with the President and Secretary as members *ex-officio*. Members of the committee are to represent production, technology, management, and the allied industries.

2. This committee was directed to establish an editorial board of from ten to twenty members to serve a minimum of one year to evaluate the suitability of meeting papers and contributed articles for publication in *Tappi*.

3. The following statements of publication policy were approved:

(a) The Association shall reserve the exclusive right to determine the disposition of papers presented at its national meetings.

(b) The disposition of papers presented at meetings of local sections shall be left to the discretion of the local section executive committees. (If any papers are deemed to be suitable for publication in *Tappi* they may be submitted to the national Secretary for consideration by the Editorial Board.)

(c) Publications, other than *Tappi* may publish condensations, not exceeding 300 words of papers presented at national meetings. These should be published as part of the text of the running story rather than as separate items.

(d) Publications, other than *Tappi*, may publish papers presented at national meetings, when granted permission to do so by the Association. (Written requests of this nature should be addressed to the Secretary.)

(e) In the event that an author of a national meeting paper arranges to have his paper published in another magazine, the Association reserves the right to refrain from authorizing its publication in *Tappi*.

FALL MEETINGS 1948

The Secretary reviewed the meetings held in Appleton, Wis. (Plastics); Madison, Wis. (Fundamental Research); Poland Spring, Me. (Mechanical Pulping); and Pittsburgh (Testing) and indicated that they were very satisfactorily attended and excellent in accomplishment. (Since this meeting of the Executive Committee, the sixth of the fall meetings was held at Peoria, Ill. on Fibrous Agricultural Residues, and was considered successful by its chairman, S. I. Aronovsky.)

COATING CONFERENCE 1949

Werner Kaufmann reported that the Coating Committee will sponsor a Coating Conference on April 25–28, 1949, at the Pantlind Hotel, Grand Rapids, Mich. Assistance in arrangements will be given by the Kalamazoo Valley Section. Two days of technical sessions will be held, one on paper machine coating under the chairmanship of Peter J. Massey of the St. Regis Paper Company, and the other on conventional coating mill operations under the chairmanship of W. A. Kirkpatrick of the Allied Paper Mills. The other days will be devoted to mill visits in the Kalamazoo area. About 300 are expected to attend.

GENERAL FALL MEETING 1949

H. W. Bialkowsky reported the progress made in the plans to hold a general fall meeting on the Pacific Coast in 1949. The meeting will be held at the Multnomah Hotel, Portland, Ore., on September 11–15, 1949. A. G. Natwick of the Crown Zellerbach Corporation, and R. J. Le Roux of the Weyerhaeuser Timber Company, Pulp Division, have been designated as general co-chairman of the meeting. In addition to the technical program there will be mill visits, a woods trip, and entertainment. A special train will take eastern members from Chicago to Portland.

ENGINEERING CONFERENCE 1949

The Fourth Engineering Conference of the Pulp and Paper Industry will be held at the Statler Hotel, Boston, Mass., on October 31, November 1–3, 1949.

ANNUAL MEETING 1949

The annual meeting of the Association will be held at the Commodore Hotel, New York City, on February 21–24, 1949. At this meeting the medal award presentation will be made at the opening session rather than at the annual luncheon as in the past years. The 1949 award will be made to Hardy S. Ferguson, Consulting Engineer, New York City.

MONOGRAPHS

Dr. Kaufmann reported that the monograph on Pigments for Paper Coating has been printed and distributed. Two additional monographs are in preparation on Adhesives for Coating and Machinery for Coating. These are being prepared by the TAPPI Coating Committee.

Mr. Gillespie reported that progress is being made in the preparation of a book on Bleaching by the TAPPI Pulp Purification Committee. The Chicago Section is preparing a monograph on Graphic Arts.

The papers presented at the Fundamental Research Meeting held at Madison, Wis., and at the Mechanical Pulping Conference, held at Poland Spring, Me., will appear in *Tappi* rather than in separate monographs.

ROUTINE CONTROL METHODS

Mr. Brabender reported that the large number of routine control methods that were collected by the local sections and other groups are being edited by Roger C. Griffin.

BOUND VOLUMES OF TAPPI

The Secretary reported that he has received about 175 requests for bound volumes of the permanent text of *Tappi*. He was therefore authorized to proceed with plans to accumulate this text for binding in 1950.

CHANGE IN BYLAWS

It was voted to amend Article V, Sec. 1 of the Bylaws to read "New members elected after January 1st and June 30th shall be liable for full or one-half of the annual dues, respectively, in the year of their election." (Note: These liabilities were formerly handled on a quarter-year basis.)

It was further voted to increase the annual dues of overseas members in 1950 from $15 to $20 to take care of the excess

postage charges. (Note: These excess charges have been collected during the past few years as an excess of the $15-per-year dues. The new arrangement simply incorporates these increases in the dues without adding postage charges as a separate item.)

STUDENT MEMBERSHIP

Consideration was given to the abolition of the present Junior grade of membership in 1950 and the establishment of a grade of student membership. Since this requires an amendment be made to the Constitution, the Secretary was instructed to prepare a statement of the proposed changes for consideration of the Executive Committee in February and for a first reading during the annual meeting.

HANDLING OF APPLICATIONS

It was voted to simplify the procedure for handling applications for membership within the Executive Committee by having the Secretary furnish Executive Committeemen with data concerning the applicants. (*Note:* This will reduce the time required to process new applications since the earlier practice consisted of circulating copies of the applications to all members of the Committee.)

NEXT EXECUTIVE COMMITTEE MEETING

The next meeting of the Executive Committee will be held in New York City on February 20, 1945.

Report of Chemical Methods Committee

MILTON F. FILLIUS

Considerable thought has been given recently to the broad objectives of the Chemical Methods Committee and to the type of standards the committee aims to produce. In the first place, it is desirable to have only one method covering a certain phase of activity. The Industry which TAPPI serves deals with a wide range of materials, and it is almost inevitable that occasionally two methods will exist for the measurement of certain constituents or properties. Whenever two such procedures are used, two complete sets of data must be built up, or else interlaboratory comparisons are impossible. Where two methods exist, the committee desires to select the best method; the most accurate and precise one.

It should be emphasized, in the second place, that the official TAPPI standards are referee methods; that is, they must be reliable, sound methods. All short cuts which might jeopardize the results must be omitted. However, the official standards should be as rapid as possible consistent with reliability and basic soundness.

Several cases have come to the attention of the committee where two methods now exist and the committee is attempting to make a choice between these two. In one case in particular, there are insufficient basic data for the committee to make an intelligent decision. One group of workers is using Modification A, another group of workers is using Modification B. Each is satisfied with the results it is obtaining. Relatively little basic information on the chemistry of the two test methods is available and the Chemical Methods Committee finds it difficult to make an intelligent decision between the two. This emphasizes the need for basic study of official methods by some impartial group such as a university or an institute. One possible solution would be a scholarship or fellowship for such projects. The experiments, if properly conducted could be made the basis of a degree thesis.

It should be emphasized again that the TAPPI methods should give reliable results for the greatest possible variety of products to be tested. For example, in the disperse viscosity procedure which is discussed below this basic question must be answered. There are investigators which use both solvents recommended in the different TAPPI procedures and each worker is satisfied with the results he is getting. In general, he works in one particular range of degree of polymerization. Some impartial worker must assemble samples over the whole D. P. range and critically study the applicability of both solvents to all of the samples assembled. Only in this way can an intelligent decision be reached. It is not enough to tabulate the number of people satisfied with the modification that they are using in attempting to assess the relative merits of the two procedures. Here again, the need for work in a university or an institute is definitely indicated. The statistical tools, which have been popularized recently, should be exploited to the full extent. All the possible variables involved in a procedure should be studied systematically by some technique such as "Latin Squares" or "Analysis of Variance."

The Chemical Methods Committee would like to reach decisions on several procedures now under consideration. However, it is necessary to make intelligent decisions. We must make a transition from mere solicitation of the opinion of a large number of workers to a procedure which in addition to this involves a basic study of the various procedures. These fundamental studies are lacking in most fields and will be gathered very slowly. In the meantime the official standard should be revised when desirable changes in technique have been found. The time required to reach a completely satisfactory solution is too long for effective functioning of the committee.

DISPERSE VISCOSITY

TAPPI and the American Chemical Society have interlocking committees on the subject of disperse viscosity. Dr. Peter VanWyck is Chairman of both committees. The problems confronting both organizations are essentially the same. In the first place, there is a choice of solvents.

Cuprammonium and cupriethylenediamine have both been recommended for viscosity work. There are essentially four different methods to choose from: two cuprammonium and two cupriethylenediamine procedures. There is a fast and slow cuprammonium method and there are two cupriethylenediamine methods included in T-230. In addition to different solvents, there are different dissolving techniques. A very rapid cuprammonium method has been frequently applied and has been accepted as a standard method in certain foreign countries. A very important phase of the disperse viscosity problem is the viscometry of the cellulose solutions. A fourth phase of the problem is that of sample preparation. This will receive more consideration in the alpha-cellulose discussion.

Solvent

The Chemical Methods Committee would like to choose one official TAPPI standard which can be used as a reference procedure in this field of disperse viscosity. The first question that must be settled would, therefore, be the selection of the proper solvent. The committee must choose between cuprammonium hydroxide solutions and cupriethylenediamine hydroxide solutions as a solvent for cellulose. This choice involves a difficult decision. The question must be clearly answered; which one of these two solvents is more nearly universally applicable to cellulose samples of varying degrees of polymerization. This question could not be answered finally at Pittsburgh. One or two workers reported some difficulty with high molecular weight materials using cupriethylenediamine; others successfully applied cupriethylenediamine as a solvent to high molecular weight materials using lower concentrations. Others obtained satisfactory data for high molecular weight materials only upon going to cuprammonium hydroxide. There is a definite need for work on

(continued on page 40 A)

MILTON F. FILLIUS, Chairman, TAPPI Chemical Methods Committee, Supervisor, Paper Service Department, Eastman Kodak Company, Rochester 4, N. Y.

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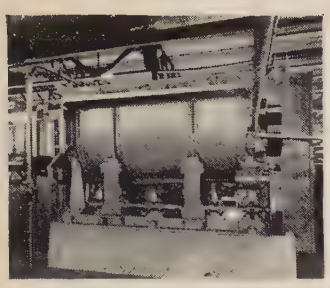

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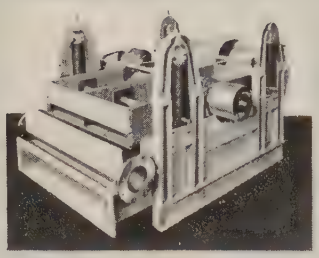

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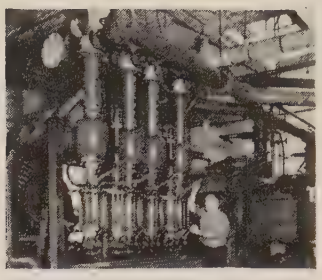

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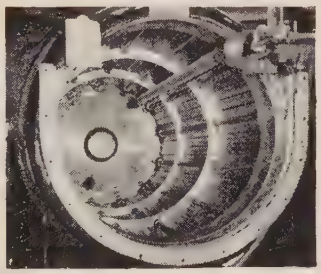

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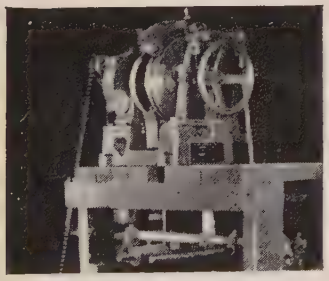

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(continued from page 38 A)

this problem by some independent, impartial laboratory which will make it a point to cover the entire range of D. P. using both solvents, so that a definite and final answer can be obtained as to the superiority of one solvent or the other. If a decision were made at this time, it is entirely possible that the wrong solvent would be selected in view of the lack of basic data.

Dissolving Technique

As a result of the discussion at Pittsburgh there were several suggestions put forward to improve the dissolving technique. One variation which is applicable to both cuprammonium and cupriethylenediamine is to treat the cellulose first with water or a very dilute solution of the solvent and then to add a portion of a more concentrated solution of the solvent to complete the dissolving. This is very essential in the application of cupriethylenediamine to high molecular weight cellulose samples, and makes the difference between a very rapid and a 15-hour procedure in the field of cuprammonium hydroxide. Another technique which was emphasized by two different workers reporting at the Pittsburgh meeting was the use of freshly cleaned copper surfaces during the solution in cuprammonium hydroxide. A freshly cleaned pure copper agitator, or little pieces of cleaned copper metal, or the use of a freshly cleaned copper vessel were among the suggestions made to eliminate the degradation due to oxygen. Evidently a freshly etched copper surface combines with oxygen more readily than does the cellulose cuprammonium system. Oxidation is thus eliminated.

Viscometry

Regardless of the solvent selected and the solution technique used, viscometry in this field will always present considerable difficulty. Any method must cover a wide range of molecular weights which means that the viscosity of the resulting solutions will ordinarily vary between wide limits. A viscometer must be selected which will measure the viscosities over this very wide range or else the concentration of the cellulose must be varied in going from one range of D. P.'s to another. There are three types of viscometers that were discussed at the Pittsburgh meeting; the capillary, the falling sphere, and the rolling sphere. The present cupriethylenediamine suggested method uses both a capillary viscometer and a falling sphere apparatus. The present TAPPI cuprammonium method uses a capillary drainage pipet. There was considerable interest shown in the rolling sphere type viscometer. A commercial instrument can be purchased or a satisfactory instrument can be constructed at a reasonable cost. The rolling sphere type viscometer offers many advantages according to the discussion brought out at the Pittsburgh meeting. The size of the spheres can be varied to cover a wide range. The density should not be varied in the opinion of workers who have had considerable experience with an instrument of this type.

Sample Preparation

Although this subject will be more thoroughly discussed under alpha cellulose, it was briefly considered at the Pittsburgh meeting during the viscosity discussion. Dr. Browning (*1*) and other workers have shown that the grinding of a cellulose sample on a mill of the Koerner-type often leads to a lowering in viscosity. It was generally agreed that such methods of preparation should be avoided. When a two-stage dissolving technique is used, the sample preparation ordinarily becomes less critical. The disperse viscosity committee intends to continue study on this point also.

No definite decisions were made at the Pittsburgh meeting but some valuable points were brought out. The disperse

(continued on page 42 A)

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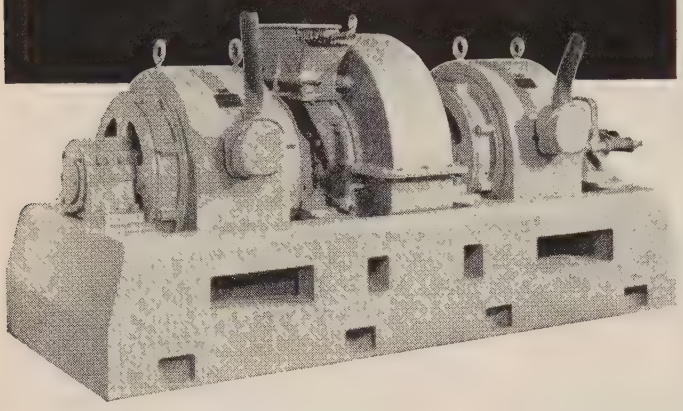

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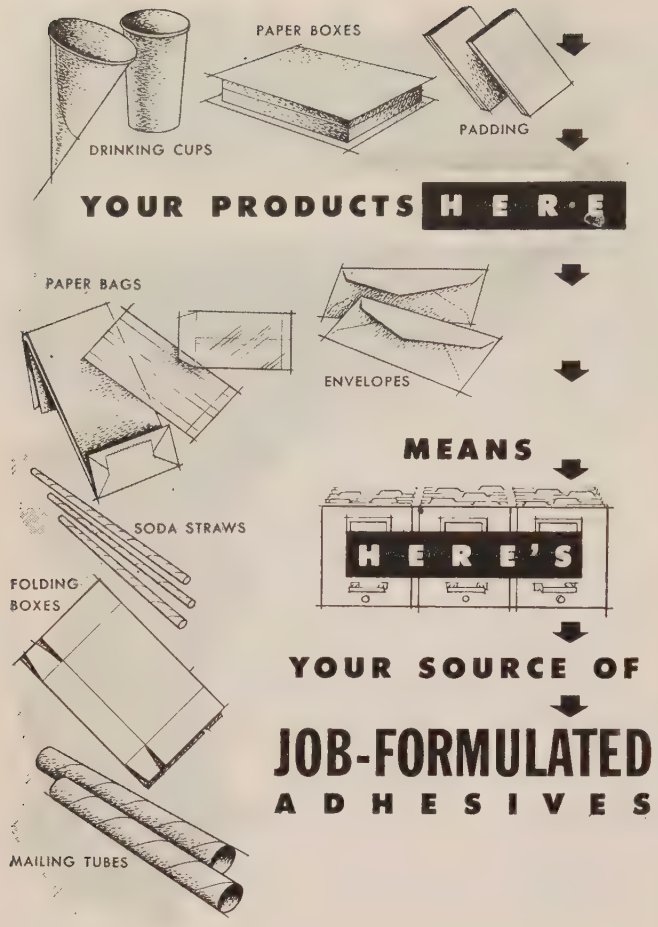

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(continued from page 40 A)

viscosity committee has considerable work ahead to answer some of the questions raised above. This they intend to do as soon as possible. Any information which can be forwarded which will assist in the proper choice of solvent dissolving technique, proper viscometer, or proper method of sample preparation will be greatly appreciated by the chairman of this committee, Dr. VanWyck. If the basic material needed to make these decisions is not available, it is the opinion of the Chemical Methods Committee that some research on the subject be sponsored so that an intelligent decision can be made.

ALPHA-CELLULOSE T-203

TAPPI and ACS have interlocking committees on alpha-cellulose, and are anxious to arrive at one procedure which can be jointly sponsored. Dr. George Ritter is chairman of the ACS committee and Dr. Albert S. O'Brien is chairman of the TAPPI committee. Recent discussions on the alpha-cellulose procedure have brought out the need for a more exact definition of the term. The very broad definition that "alpha-cellulose is that fraction of the material which does not dissolve in 17½% sodium hydroxide" is not sufficiently definite. The recent discussions, particularly those at Pittsburgh, have brought out that in the last analysis alpha-cellulose is defined by the details of the procedure used to determine it. As the alpha-cellulose is now determined by the TAPPI, and more particularly by the ACS method, the definition of the term, "alpha-cellulose" would be, "That fraction of bleached pulp which is not soluble in 8.3% sodium hydroxide (and the wash water used to remove the alkali) after first being treated with 17½% sodium hydroxide." In other words, in any practical method for the determination of alpha-cellulose, it is necessary to remove the sodium hydroxide which is left adhering to the fibers. In so doing, the alkali is diluted and this dilution and the washing which follows affect the results.

The alpha-cellulose residue should be corrected for ash as this represents inorganic material. However, it does not seem advisable to correct the alpha-cellulose residue for the traces of lignin it might contain or for the slight amount of pentosan material which resisted the dissolving action of the sodium hydroxide. There are traces of pentosan and hexosan material in the cellulose chains and so long as there is agreement on this point the residue need not be corrected for these materials. There is a separate paragraph in T-203 which deals with determination of alpha-cellulose in pulps which contain lignin. This particular part of the procedure is not being considered at the present time, but the method for essentially lignin-free (bleached) pulps will be revised.

The alpha-cellulose method is empirical and every step must be specified. However, it is evident that every operation is not equally significant as was brought out by the "Statistical Study of Some of the Variables of the Alpha-Cellulose Procedure" (*2*). As a result of the discussions at the TAPPI Meeting in February, 1948, and at the April, 1948, meeting of the Cellulose Division of the American Chemical Society, the variables were arranged into two groups: slightly significant, and highly significant. The slightly significant variables were such things as sample size, method of stirring, method of addition of sodium hydroxide, acetic acid rinse, temperature, etc. These variables should be fixed in any procedure, but being only of slight significance they may be specified in less detail.

The important variables which must be rigidly controlled are:

1. Method of sample preparation.
2. Dilution of the 17½% sodium hydroxide prior to filtration.
3. Determination of the moisture content of the pulp samples and drying of the alpha-cellulose residues.

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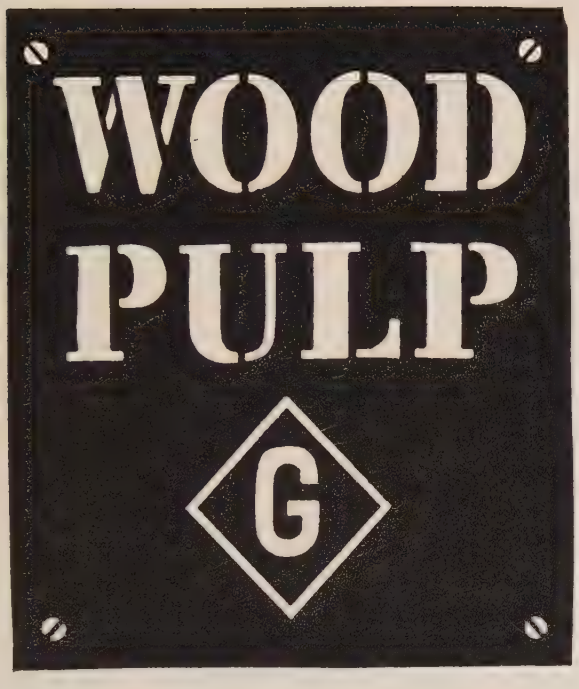

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(continued from page 42 A)

Sample Preparation

There has been considerable criticism of the use of a grinder of the Koerner type. Browning (*1*) showed that the alpha-cellulose is lowered appreciably by a grinding procedure. This was verified by other workers. One of the speakers at the round-table discussion at the April ACS meeting pointed out that grinding does not necessarily lead to degradation. He cited experiments which showed that a careful grinding procedure lowered the alpha-cellulose appreciably but did not lower the viscosity and since viscosity is considered the best measure of degradation, it was concluded that careful grinding could lead to lowering of alpha-cellulose without actual degradation. At the Pittsburgh meeting it was pointed out by Dr. Aronovsky that this lowering of the alpha-cellulose values may be due to the colloidal dispersion of finely pulverized material produced by grinding. The opinion of the group at Pittsburgh seemed to be that the most practical method of sample preparation was the use of half-inch squares of lap or pieces of similar size.

Dilution of the 17½% NaOH Just Prior to Filtering

The matter of dilution of the mercerization solution just prior to filtering was the subject of considerable discussion at the Pittsburgh meeting. The discussion was introduced by Dr. O'Brien who pointed out that a variety of answers could be obtained for the alpha-cellulose content of the pulp depending upon the technique used at this point in the procedure. On one extreme is the present ACS method which dilutes the 17½% sodium hydroxide to 8.3% and allows the diluted slurry to stand for one hour to reach equilibrium. Considerable more material goes into solution as a result of the dilution and standing and a minimum value for alpha-cellulose is obtained. On the other extreme, if the residue is separated from the 17½% sodium hydroxide directly without dilution and washed with fresh portions of 17½% sodium hydroxide and then washed with a saturated salt solution, a maximum value for alpha-cellulose is obtained. Intermediate values for alpha-cellulose can be obtained depending upon the manner in which the residual sodium hydroxide is removed. The most interesting experiment reported was that a very quick rinse of an alpha-cellulose residue, which contained only a small amount of 17½% sodium hydroxide retained in the pad, led to a lowering of 2%. That is, if the residue is washed with fresh portions of 17½% sodium hydroxide without any dilution and then the excess solution removed by suction, a quick wash with a large volume of water at this point would remove an additional 2% of material in the case of the particular pulp being reported. The TAPPI procedure approaches the ACS but, since the time of standing in the diluted state is very short, values are slightly higher.

There was a very profitable discussion at the Pittsburgh meeting on this matter of dilution. By way of summary, it can be said that it did not appear wise to the group assembled at Pittsburgh to adopt any intermediate procedure, but that a method which gives either the minimum or the maximum value should be selected, that is, alpha-cellulose should be looked upon as that fraction which does not dissolve in the 17½% sodium hydroxide in which case the technique leading to the maximum value should be adopted, or else in line with the procedure which has been in use for so many years, the definition should be changed to that fraction of the cellulose pulp which does not dissolve in approximately 8% sodium hydroxide solution after first being treated with 17½% sodium hydroxide. The group felt that either one of these two extremes should be selected and that any modification which gave a value in between would be hard to

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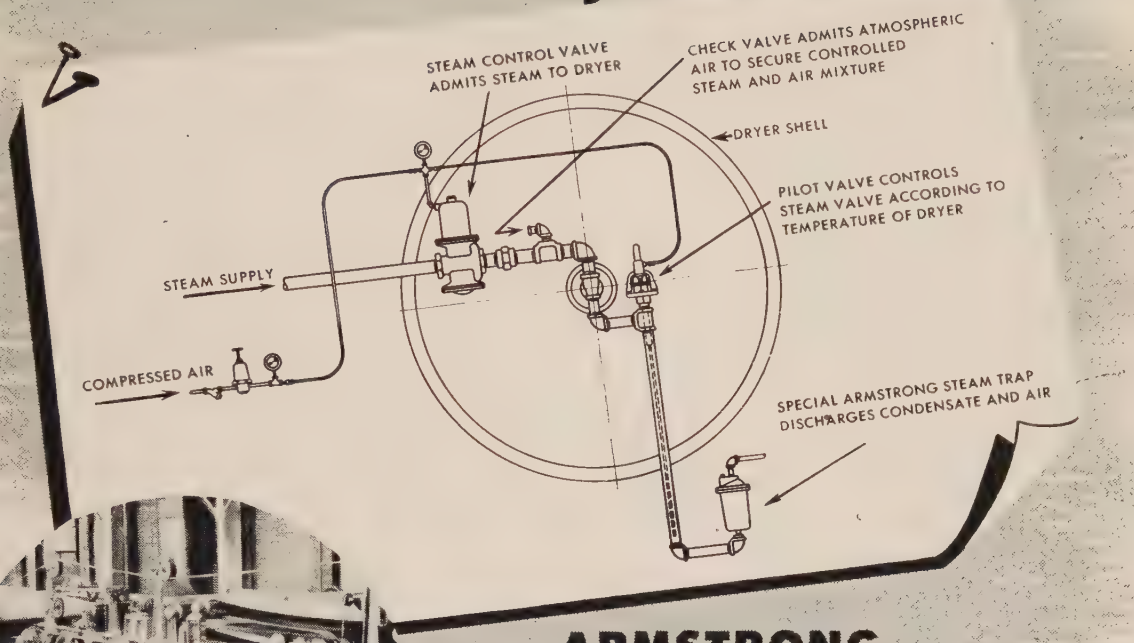
A NEW ANSWER

to an old drying problem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CHECK VALVE ADMITS ATMOSPHERIC AIR TO SECURE CONTROLLED STEAM AND AIR MIXTURE
DRYER SHELL
PILOT VALVE CONTROLS STEAM VALVE ACCORDING TO TEMPERATURE OF DRYER
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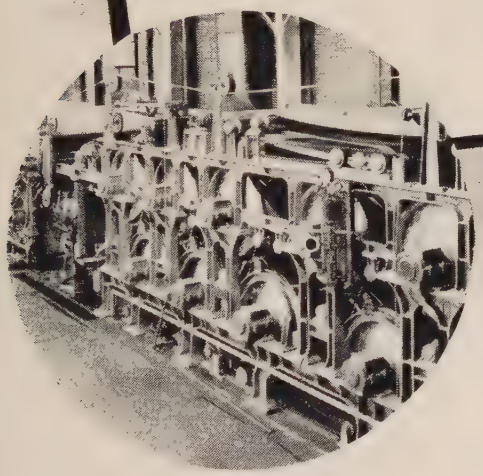
SPECIAL ARMSTRONG STEAM TRAP DISCHARGES CONDENSATE AND AIR



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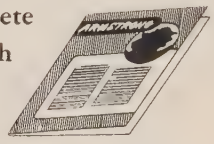

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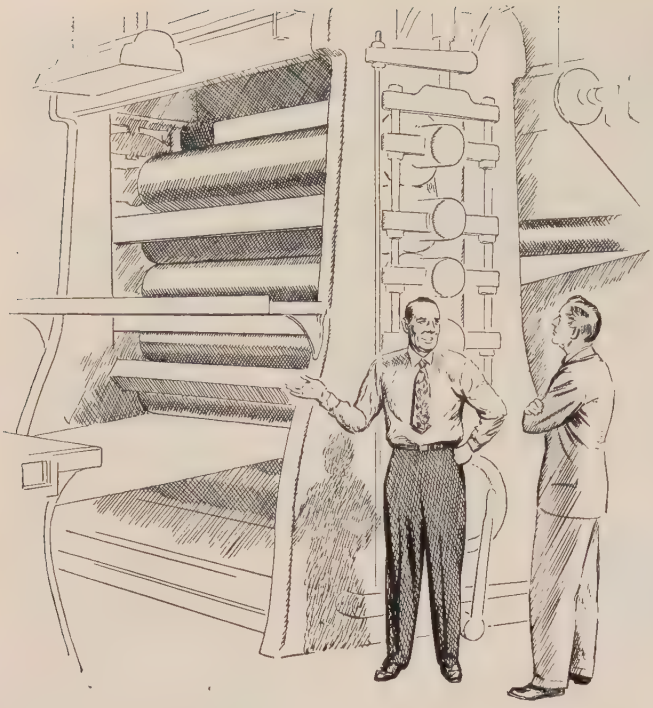

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Butterworth Calender Rolls

(continued from page 44 A)

justify from a theoretical point of view. It was brought out at the Pittsburgh meeting that the Scandinavian pulp industry has two different alpha-cellulose procedures, one called the "A" and the other called the "B" modification, which were adopted to satisfy those branches of industry which desire to have a maximum and a minimum value for the alpha-cellulose content of pulp. It is possible that TAPPI and ACS should consider adopting two different procedures although, in general, it is advisable to avoid this if possible. It may be that certain industries are anxious to know the minimum value which can be obtained for alpha-cellulose content, that is, a procedure which will remove a large percentage of borderline molecules and another industry may like to have an alpha-cellulose value which includes these borderline molecules. The consensus of the Pittsburgh group seemed to be that in view of the historical background and the accumulation of the data obtained by the dilution technique, that TAPPI should go over to a procedure which is essentially the same as ACS. In other words, an attempt should be made to get an equilibrium with the 8.3% sodium hydroxide and thus remove all of the borderline molecules from the alpha-cellulose residue. It was further suggested that the procedures adopted by the Scandinavian Paper and Pulp Engineers Association be studied with a view toward adopting or at least seriously considering their method of getting two different answers for alpha-cellulose.

The Moisture Content of Pulp

Every alpha-cellulose determination assumes that the exact moisture content of the original sample is known. At the February, 1948, meeting of TAPPI it was brought out that the moisture determination is extremely important and unless great care is taken, these variations can materially affect the results. It was pointed out at that time that it was practically impossible to get a sample of uniform moisture content regardless of the method of conditioning, and that unless great care is taken a correct moisture value cannot be obtained even if a uniform sample were available.

When drying down in a regular laboratory oven, it was found that the final weight of a residue is to a certain extent dependent upon the relative humidity of the laboratory air being circulated through the oven. In view of this, a recommendation was made at that time that the samples to be used for an alpha-cellulose determination be dried individually in a vacuum oven at 50 or 60°C. No degradation takes place at this temperature. In this way a moisture determination is eliminated by using absolutely dry portions of pulp for the alpha-cellulose determination. This technique saves two precise weighings and introduces one rough weighing. At the Pittsburgh meeting there was some strong support from the floor in favor of vacuum drying, and it seems advisable now to include the vacuum drying technique as part of the official standard. It will also be recommended that the alpha-cellulose residues be taken to constant weight in a vacuum oven.

THE pH of PAPER EXTRACTS T-435

A third method which has been before the Chemical Methods Committee for some time, and upon which it seems difficult to reach a final decision, is the proper technique for the determination of the pH of paper extracts. At the present time there are two extraction techniques recommended in the TAPPI Standard T-435. One is an extraction with cold water and the other is an extraction with hot water.

At the Pittsburgh meeting an attempt was made to get all the basic information possible which could lead to an intelligent decision. It would be an easy thing to pass ballots around and ask people to choose between a hot or a cold extraction, but there seems to be a need first of all for some

(continued on page 48 A)

for STOCK PREPARATION

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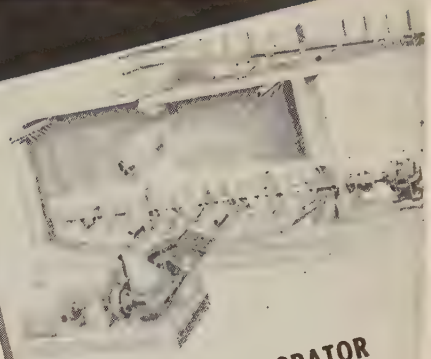

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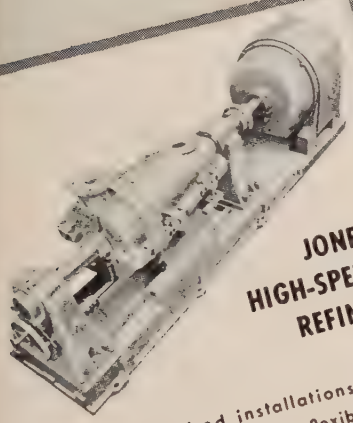

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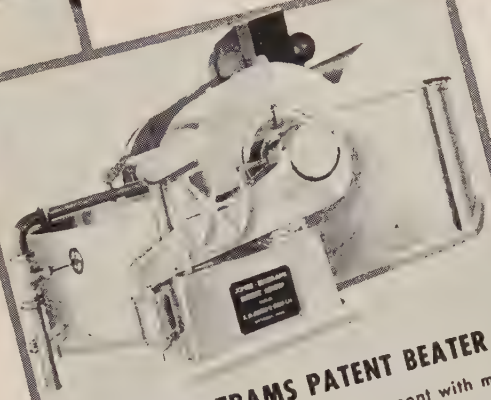

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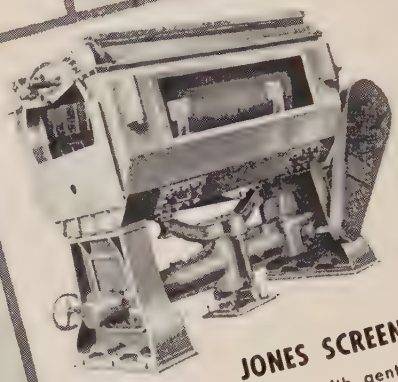

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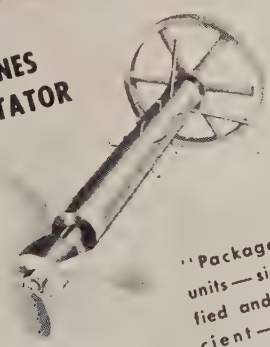

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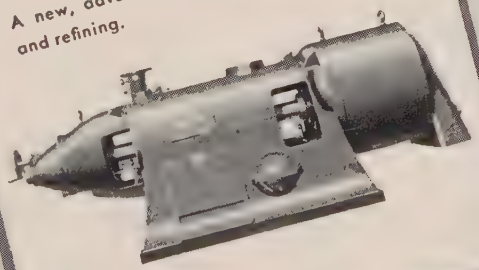

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(continued from page 46 A)

basic information on the chemistry involved in the hot and in the cold extraction. In order to make an intelligent choice, a chemist must know what the choice involves. If we must decide that a hot extraction is fundamentally more sound, we must understand a little about the chemistry of hot extraction, and if the cold extraction is fundamentally to be preferred, the chemistry of the cold extraction must be contrasted to the chemistry of the hot. This is admittedly a difficult field. The hydrolysis of sizing materials at different temperatures is by no means a simple problem, and, furthermore, how these two hydrolysis conditions are related to permanence is still another difficult question to answer. The pH of paper extracts seems to be another procedure which requires some basic study, However, it does not appear to be nearly so important as the subject of disperse viscosity which should be given preference in any fundamental and statistical study. The survey which was conducted recently by the Testing Division showed that a relatively large number of workers used both the hot and the cold procedures, although the hot extraction seemed to have a few more adherents than the cold. In view of this situation it does not seem advisable to vote out either procedure until more information is obtained on the basic reactions at the two temperatures and their relation to permanence.

OTHER PROCEDURES CONSIDERED FOR REVISION

Other projects are under consideration in the Chemical Methods Committee. A sub-committee has been appointed on the general subject of sample preparation. A sub-committee is also being formed in the field of Bleachability of Pulp which includes the Potassium Permanganate Number and Chlorine Number Procedures. The main committee would like to know whether these methods can be combined into one official TAPPI Standard.

A newly formed sub-committee on wood methods is preparing some new procedures and has three of the present TAPPI Standards under consideration for revision. Prof. E. F. Kurth, who has recently joined the Chemical Methods Committee, is the chairman of this new sub-committee. Dr. Kurth is an authority in the analysis of wood, and his addition to the group has greatly strengthened the committee.

THE TAPPI SURVEY

The questionnaire sent out during the summer of 1948 has furnished a large amount of useful data. Mr. Roger C. Griffin has recently made a preliminary tabulation of the results and a large number of facts can be gleaned from these tables. More work must be done to get the opinion from workers expressing dissatisfaction with individual methods. Some find certain TAPPI standards unsatisfactory and are using a method of their own which, in their opinion, gives good results. The reasons for their dissatisfaction, and the points at which their substituted methods differ from the TAPPI standard must be assembled and analyzed.

From the data of the survey certain general conclusions can be reached. The total number of replies received on the various methods give a measure of interest that exists in the procedures. Certain standards received a total of 15–20 replies, and others over 100. This indicates where the interest of the industry lies, and will guide the Chemical Methods Committee in its choice of projects.

Not only is the total number of replies received on a method of importance, but the percentage of answers expressing dissatisfaction must be carefully studied. If, for example, 50% of the replies indicate that the TAPPI standard is unsatisfactory or that a modified TAPPI procedure is used, or that another unofficial method is employed, the standard in question is undoubtedly in need of revision.

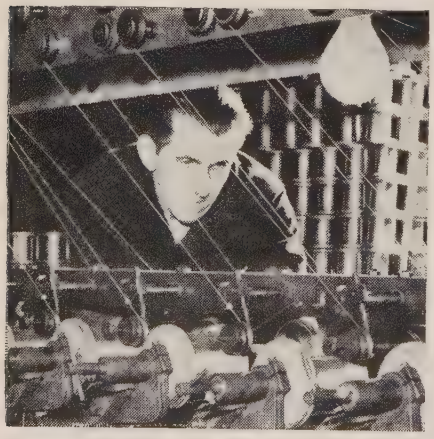
Previously it has been difficult to decide which TAPPI Standards should receive attention from the Committee. We can now answer some of the previous questions such as: How many are dissatisfied with the present Standard? Is there enough interest to justify some basic study of the procedure? What part of the industry has trouble with the method? Which standards should be recommended for basic study at some university or institute? Are there private laboratories sufficiently interested in the project to do some systematic work using their own facilities. The survey will help in answering these questions and was, therefore, very worth while, provided the preliminary data are followed up properly. The selection of future projects and subsequent work and recommendations of the committee will be strongly influenced by the results of the survey.

A number of methods not now being considered for revision but which were rather strongly criticized in the recent TAPPI questionnaire are: The Reducible Sulphur Content of Paper, Resin in Paper, the Determination of the Amount of Coating Material on Paper, Starch in Paper, and the Total Acidity of Paper. These all represent possible future projects for the Chemical Methods Committee.

LITERATURE CITED

1. Browning, B. L., *Paper Trade J.* 124: no. 15 (T.S. 158–9), April 10, 1947.
2. O'Brien, A. S., Reitz, L. K., and Bloom, R. C., *Paper Trade J.* 127: no. 6 (T.S. 340–3), August 5, 1948.

Ed. Note: This report by Mr. Fillius is a clear-cut statement of some of the major test method development problems confronting his committee. Within the Technical Association there may be some members, not on the committee who can offer the committee valuable suggestions based on their own investigations. This magazine provides an unusual opportunity for committee chairmen to reach many who can offer assistance. It will simplify matters for everyone if such responses are sent to the Secretary of TAPPI, 122 East 42nd Street, New York 17, N. Y. They will be forwarded to the proper destinations.



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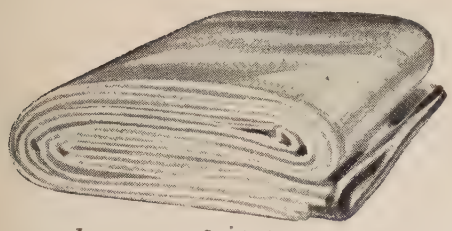

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TO MAKE A
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After it has been shrunk and fulled every Hamilton Felt is gently combed by a million needle-pointed cockle burrs (teasels) which free the matted fibers and *fluff* the nap until every square inch of its surface becomes an even and resilient cushion for the speeding web. Less heat is needed at the driers. No impressions mar the smoothness of the finish.

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REPORTS AND DISCUSSIONS

Presented at National and Regional Conferences

TAPPI Materials Handling Committee

Mr. George R. Wadleigh, Chairman of the TAPPI Materials Handling Committee, has supplied the following notes relative to the Materials Handling Session and the Round Table conducted at the Third Engineering Conference of the Pulp and Paper Industry at Buffalo, N. Y., on October 25–27:

In the general session attended by nearly three hundred engineers, representing more than one hundred pulp and paper mills, only seven companies reported having a specific materials handling engineer, even though the materials handling cost approaches that of power.

CENTRALIZED TRANSPORTATION SYSTEM

Mr. G. L. Hawkins of the Hammermill Paper Company presented a paper on "A Centralized Transportation System for a Pulp and Paper Mill." In this paper he indicated that the important factors to be considered in selecting materials handling equipment are (1) height between floors; (2) condition of floors; (3) width of aisles; (4) type of material, i.e., loose, baled, boxed, etc.; and (5) location of various buildings with respect to routing.

In response to an inquiry Mr. Hawkins estimated the cost of handling dry materials in a paper mill as 4.5% of the total cost, while inclusion of pumping costs would raise this to 10–15% of the total cost.

WOOD HANDLING IN THE WOOD YARD

Hammermill is experimenting with a new load wheel on their trucks that will reduce the chipping and dusting of floors caused by the standard steel wheel. A wheel developed by Mr. Goodrich has given favorable results during its three-month test.

Mr. Hawkins stated that the trend at Hammermill is toward the use of smaller trucks, with doors being one of the limiting factors. Many doors had to be enlarged to eight feet by eight feet. Primary aisles are eight feet wide; secondary, six feet.

At the present time, Hammermill fills their beaters, using electric trucks, but they are planning to install slush pumps thereby eliminating electric trucks in the beater room.

WOOD HANDLING IN THE YARD

Mr. John A. Willard, of Bigelow, Kent and Willard, presented a paper entitled "Methods of Wood Handling in the Wood Yard." The three methods of delivering wood to the wood yard are by river, rail (flat or box car), and trucks. The economical limit of trucking is about 50 miles.

Mr. Willard showed photographs of various methods of handling wood in Sweden. In rail delivery, one rail is depressed, and the wood skidded from the car to the river. The wood is sorted in the river by size and kind, thereby providing straight-through handling. The wood is then picked up by a chain conveyor, submerged at the lading end, and carried thereby to a gang saw.

A wood inventory in the yard is necessary to assure continous feed to the mill. In the Middle Atlantic states, this inventory may amount to one-third of a year's supply. In this connection, Mr. Willard referred to an important paper prepared by Prof. Mathews, University of Michigan, and published by the A.S.M.E. in 1945 titled "Preplanning of Logging Operations for Minimum Cost."

The yard must be laid out to avoid delays in unloading trucks. The best method is to use dump trucks together with an unloading ramp in the yard. The principal drawback to this method arises from the inability of wood contractors to finance this type of truck, which forces the mill to purchase them.

The Bangor and Aroostook Railroad have developed a side-opening open top car for wood, but other railroads believe this system to constitute a potential danger to passing trains. Still on the drawing boards is a pneumatic pusher to push out the center section of wood in a box car. The use of an orange peel or grab bucket is comparatively expensive.

Mr. Willard then discussed the time required for unloading in terms of units, a unit consisting of 160 cubic feet of wood five feet long, averaging 8 1/2 inches diameter, rough. Efficient unloading of a box car approximates 2.2 units per man hour, although the average is three units. A 30% saving can be accomplished by tilting the car. Larger diameter wood takes twice as long. Trucks unloaded by hand average 1.6 units to 2 units per man-hour (25 minutes per truck). An orange peel bucket can move from 1/2 to 3/4 unit per trip and can make about 40 trips per hour. The cost ranges from 20 to 30 cents per unit.

Drag chains are often used in conjunction with an orange peel bucket to reclaim where inventories are small. An effective method is the use of flues. Concrete flues require a high first cost, low maintenance, but additional cost data is necessary before this method can be completely analyzed. Other methods include trucking and overhead cable and button conveyors. One system shown by Mr. Willard involved an 80-foot lift, 200-foot length, with 8-foot button spacing. An orange peel bucket loaded the lower strand for reclaiming.

The ideal barker still remains to be developed. Drum barkers pound the wood too much, hydraulic barkers consume too much power.

In reply to a question about chain conveyors, Mr. Willard stated that he had often seen the failure of one link make 15 men idle. He therefore does not favor chain conveyors.

NOTES ON ROUND TABLE DISCUSSION

1. Handling Dried Broke Back to Beater

Mr. S. L. Foster, Kalamazoo Vegetable Parchment Co., stated that the broke, at the end of a run, is dropped to a baling machine on a lower floor. The broke is treated in batches using a Claflin jordan. The broke is then fed back at a uniform rate into the stream after the stock is refined. This may amount to 3 to 3 1/2%. A hydrapulper will handle 6%. A uniform amount of broke is placed in each beater. The principal variable is the amount of broke. Broke from a previous run of similar paper is taken out of dry storage, so that the operations may start with the normal amount of broke.

Wet strength broke and newsprint broke require different treatments. In the case of bond paper, the operator must provide for the removal of broke specks. No single method can be applied generally.

Discussing the handling method further, Mr. Foster stated that two or three bales are handled by a gasoline lift truck per trip. A table conveyor is located in front of the hydrapulper to receive the charge. Inspection at this point saves time. The conveyor is 24 inches above the floor level while the rim of the tank is below the floor. While small mills

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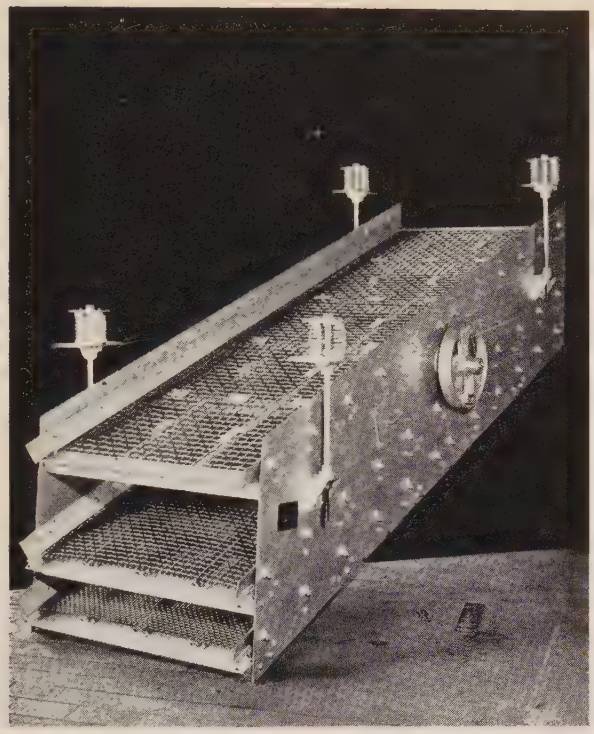
THE CARTHAGE DILLON SCREEN



Simple In Design—Only Two Bearings

Low Upkeep and Power Consumption

Balanced Action

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(continued from page 50 A)

may not have hydrapulpers, beaters, when idle, can be used on broke. Broke may be fed by air to the beater departments.

2. *Electric vs. Gasoline Lift Trucks*

Mr. S. L. Foster stated that his Company had had excellent experience with both electric and gasoline lift trucks. The small transporter trucks are all electric, while the large trucks are gasoline. Gasoline operation requires good ventilation, while ramps tend to reduce the life of batteries. Their experience indicates that there is little difference in maintenance costs. Another person stated that he preferred gasoline trucks after using both kinds, despite the fact that gasoline trucks are twice as expensive and require more maintenance than electric trucks. Battery trouble offset these other difficulties.

A representative of the Clark Equipment Co., manufacturers of both gasoline and electric lift trucks, said that while the electric truck does not require as much maintenance, it is not as effective as gasoline trucks on ramp work, and the batteries require charging after 8 hours. Operating 24 hours a day, gasoline trucks are more economical on a per ton moved basis.

The experience of one representative indicates that gasoline operation is 40% cheaper per ton of material handled than with electric trucks. For small, short runs, electric trucks are superior, but for long runs or work on grades, gasoline is better.

3. *Palletizing*

Hammermill Paper Company palletizes all their products. They keep all the pallets at the mill, since disposable pallets are still too expensive and since their customers are not generally equipped to unload with a lift truck. Furthermore, their selective selling requires shipments of various sizes of cartons, cases, rolls, skids, etc. The trade does not deal in a palletized unit load (14 to 16 cartons per pallet).

Hammermill introduced palletizing in their mill because of space limitations, and labor difficulties in stocking to a height of 12 to 14 feet.

Mr. Stocker, materials handling expert, said that palletizing requires wider aisles, but the material may be piled higher. He said further that metal pallets have a high first cost, but lower maintenance, when compared to a wood pallet. The disadvantages of metal pallets include the need for skilled truck operators in making pickups, expensive damage when dented, heavy weight (tare), apt to be slippery, subject to rust in damp atmospheres.

In the case of multistory building operation, a roller conveyor outside the elevator door can hold the pallet until the elevator is available. Another roller conveyor inside the elevator enables the operator to push the pallet into the elevator.

The Clark Equipment representative said that fumes from gasoline trucks are a question of maintenance. A velocity type of governor is excellent for ramp work and eliminates fumes.

4. *Chain vs. Belt Conveyor in Woodyard*

Mr. Foster stated that two 500-foot centers, button cable conveyors at their mills require 200 hp. to start, 150 hp. to drive. Maintenance cost is high. Each conveyor carries 50 cords of wood per hour. They handle wood to and from their barking drums with a belt conveyor on a 10% slope. They do not consider the maintenance of a belt conveyor unduly high.

In handling wood on a belt, they found that a sudden load of logs will stall the belt. Sides must be built along the belt, otherwise the logs are bumped off the belt by the action of the belt riding over the idlers. Their experience covered 22-inch wood of about 15 inch diameter.

Flumes are expensive to build, and most of the velocity of the water is along the top surface of the water. Residual wash water is used.

5. *Use of Wide Chains to Take Wood Out of Pond*

Mr. Foster stated that the best installation that he knows about is at Bathurst, in northern New Brunswick, Canada. The wood is collected in a tidal basin. Propellers are used to force water currents to carry the wood in the desired direction. This greatly speeds up the work of the men sorting the wood. About 2000 cords of wood are handled per 8-hour day.

Paper Drying Discussion

Ed. Note: Prior to the Third Engineering Conference of the Pulp and Paper Industry, sponsored by the Technical Association at Buffalo, N. Y., on October 25–28, 1948, the engineers of the industry were given an opportunity to present questions regarding any phase of the paper-drying operation on which they cared to have advice.

These questions became the basis of a round-table discussion of the TAPPI Drying and Ventilating Committee, under the chairmanship of A. E. Montgomery. Although each question led to considerable discussion the information is condensed in the following report to give the main comments. The names of the inquirers and respondents are deleted. Following are the questions and answers:

1. Q—*When and where should drier felts be used on a machine making 9 and 12 point paper?*
   A—The function of the drier felt is to carry paper through driers and press them against the driers. They are especially valuable with light Fourdrinier sheets because they cannot have tension exerted. They might be worth while for all lightweight sheets.
   A—Felts give good surface by their ironing effect as contrasted to drying without felts which gives blisters.
   A—Drier felts improve drying capacity and bottom drier felt helps prevent wrap-around.
2. Q.—*What type felts, cotton, or asbestos are recommended and what range of temperature to use for each?*
   A—The type of felt is not determined by temperature requirement.
3. Q—*What is the effect of superheat in drier steam supply?*
   A—There is little effect because the 50 B.t.u.'s offered by superheat is little compared to the heat of vaporization of 1100 B.t.u.'s per pound. Furthermore any condensed moisture will render steam saturated.
   A—Superheat from the control standpoint is bad. Steam joints and bearings give more trouble with superheat.
4. Q—*Does superheat cause uneven drying?*
   A—Everyone complains of nonuniformity with superheat.
   A—Superheat is difficult to control. The temperature control is irregular.
   A—With changing loads, superheat varies 10 to 50 degrees.
5. Q—*Is there not less heat per cubic foot with superheat?*
   A—With adequate size piping this would not matter. The advantage of temperature is offset by the lower rate of heat transfer. Reference was made to a statement in "Heat Transmission" by McAdams to the effect that superheated steam has been found to transfer heat at a rate only slightly higher than saturated steam. McAdams cites an example with 180°F. superheat. The rate of heat transfer was only 3% more than for saturated steam at the same pressure and with the same wall temperature.
6. Q—*How is paper affected on the machine if the felt driers make a felt too hot?*
   (Some uncertainty existed as to what was meant by this question.)
   A—This should not be a problem on wet end.

(continued on page 54 A)

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(continued from page 52 A)

7. Q—*Could dryer felts be too dry?*
   A—If the sheet leaves at 8% this trouble should not occur, but with 3% exit moisture it might be critical.
   A—High drying rates are always accompanied by tight felts. (Cited need for instrument to measure moisture content in drier felt when running—analogous to surface pyrometer.)
8. Q—*How can uniform drying across the sheet be obtained?*
   A—It is hard to conceive that the drier could be spotty on inside.
   A—Since we are agreed the inside is all right it must be the outside—therefore a function of the movement of air.
   A—The outside edges of driers showed 20 degrees hotter than center because of high heat transfer to end.
   A—Cockling is corrected by taking the tension off draws.
9. Q—*What is the effect on cockles or grainy edges by splitting drive section at wet end of machine?*
   A—Grainy edges are improved by the Grewin system.
   A—Grainy edges are not due to faster drying at edges. This is proved by splitting paper near the center at the wet end in which case grainy edges will form even at the center of the machine. Grainy edges may be due to stock preparation or any factor which affects shrinkage.
   A—Grainy edges can be due to formation and can be corrected by adjusting slices.
10. Q—*What are some recent developments in the use of hot water from the Briner recovery system?*
    A—Water is heated for use in showers, beaters and in mill water supply system. There are still other uses we don't know about.
    A—With present increased steam costs our Committee should devote more time to study of heat economy.
    A—In board mills this should tie in to heating requirements, especially in light of the turbine talks we heard yesterday.
11. Q—*Have any attempts been made to cover in and ventilate wet ends of machines?*
    A—In Canada there is much condensation from wet ends during winter. Four mills have hoods over wet end due to high temperature of stock on old machines. New machines with proper ventilation do not need such hoods.
    A—I have seen closely fitting hoods over steam showers in West Coast mills.
    A—Will operators tolerate hood on wet end? They probably want it free.
12. Q—*Is spot cooling used around the machine room in summer time?*
    A—Yes.
13. Q—*What conditions are considered acceptable (temperature and humidity) at wet end and dry end?*
    (It was felt that this varied so greatly depending on other conditions that it could not be given a firm answer.)
14. Q—*Has anyone tried acid cleaning of driers and if so was the heat transfer rate through the shell increased?*
    A—Mr. Doughty for our Committee circulated a questionnaire which showed the results to be inconclusive.
15. Q—*We would like comments on ventilation in machine room having two or more machines with no windows in the buildings?*
    A—Two or more machines is the crux of the question. The only thing to do is install air make-up units around buildings and use machine air system from room supply rather than take in fresh air.
    A—The important thing in this case, especially in summer, is to bring air directly into the working zone.
    A—108,000 cfm. supplied in aisles between five machines and still unsatisfactory during summer months is the case in our mill. It is delivered through slotted ducts 10 feet above the floor. We tried blowing it at 6 feet and directly down on the floor. It was still unsatisfactory because operators must go into cool places from hot zone.
    A—There are two things to substantiate this contention. There is very little for men to do when the machine is running all right, so the men are inactive and much more liable to catch cold. Doctors say that an active man can stand a draft much more than an inactive man. Furthermore there is a problem due to the graduation of ages of workers. What suits grandpa doesn't always suit his grandson.
16. Q—*What is the drying rate as sheet progresses through drier section—in other words, the increment rate of evaporating?*
    A—This concerns the work done by our Drying Committee on the variation in drying rate through the drier section. We have considerable data which we expect soon to have published. Surprisingly, the drying rate is fairly constant from the wet end to the dry end of a machine if the steam pressure is uniform, until the moisture content of the sheet is down to about 10 or 15%, depending upon the type of paper.
17. Q—*What is the effect of stock freeness on drying?*
    A—The TAPPI drying rate reports always failed to show any difference in drying rate between free stock and slow stock. On the questionnaires for paper board and for kraft we asked whether the stock was free or slow on the data reported and in each case there was no material difference in drying rate. Likewise the drying rate for the extremely slow glassine stock is much the same as for the very free papers.
    A—I disagree. I am sure that a free stock does dry more easily.
18. Q—*Effect of stack hardness on drying?*
    (There was an uncertainty as to what was meant.)
19. Q—*What is the benefit of drier felts vs. no felts?*
    A—This question was partially answered earlier. On kraft board machines in the south there is much experience on the effect of drier felts either partially or entirely through the drier section on the production and the general consensus is that the full use of drier felts gives the most drying.
    A—With reservation that felts are kept dry.
    A—Felts also should be kept tight.
20. Q—*What is the benefit of felt driers vs. no felt driers?*
    A—There can be too many felt driers just as there can be too few.
21. Q—*What is the effect of slush vs. dry finish on driers?*
    (There was an uncertainty as to what was meant.)
22. Q—*What is the effect of seasonal changes particularly relative humidity? Would dehumidification be economically sound?*
    A—Mechanical dehumidification is not economically feasible.
23. Q—*What is the best location for a smoothing press in the drier section on a board machine, and weight required?*
    A—One half way down the drier section and a pressure of approximately 200 pounds per lineal inch.
24. Q—*What is the effect of relatively high temperature drying of book and similar papers, either over conventional driers with steam up to 150 p.s.i. or by radiant heat in one form or another. Assume that the problem is one of increasing production over existing driers?*
    A—Radiant heat might give discoloration. On bond paper production has been increased 25% with high steam pressure and with no adverse effect.

(continued on page 56 A)

PIONEERS TOGETHER

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(continued from page 54 A)

25. Q—*How should heating coils in roller drier be drained?*
A—Use high pressure drainage system.

26. Q—*The factors commonly considered in deciding the number of driers required are: Weight of sheet, density of sheet, moisture entering, moisture leaving, speed, nature of dry felt, dryness of dry-felt, steam pressure, sweep of ventilating air, humidity of air, temperature of air, air removal from driers, water removal from driers, total contact surface.*
Less commonly considered are: Shell material, shell thickness, nature of drier surface inside, felt tension, condition of steam, application of steam, arc of drier contact.
Concerning this last, it is easy to conceive of a sheet being in contact with any one drier too long for optimum use of surface as a heat transfer agent. The question is—Have not large diameter driers, excluding Yankees, other conditions being equal, a lower average drying rate per square foot than those of small diameter?
A—This is a matter on which no proved information can be available. We doubt that large diameter driers as normally used can have lower drying rate because of length of time of contact, but, as has been stated before, large diameter driers give a lower unit pressure of the sheet against the drier surface than smaller diameter driers with the same sheet tension. This does result in lower drying rates. We believe thickness of sheet so small that reversal of heat transfer from one side to the other should not be of too much importance.

27. Q—*What volume of air per pound of paper to be dried is considered good practice in estimating for capacity?*
A—Each machine must be considered separately because of many variables.

28. Q—*Do you know of any mill where the exhaust from the machine hoods is cooled in washers or other equipment, then reheated and returned to the machine room? Do they mix in some outside air before returning it to the machine room to reduce relative humidity in the air returned?*
A—Write Mr. Hooper of Ross Engineering in Montreal for developments in Canada.
A—Plans have been made for hooding one machine completely to the floor and totally enclosing the machine in the basement and then taking all of the exhaust from the machine through air washers for dehumidifying it, thereby heating water and reintroducing the dehumidified air to the machine after reheating it. If carried to its ultimate conclusion there would be no exhaust from such a paper machine.

29. Q—*What is considered the most economical relative humidity to run on the exhaust of a Yankee hood ventilating system? In connection with this what is the probable percentage of air that may be recirculated to obtain the desired results? What is the economy of recirculation? Drying capacity with and without recirculation?*
A—Relative humidity of the exhaust on a Yankee machine is dependent on many variables, but it is possible to carry a higher percentage of relative humidity on a Yankee machine than on a conventional Fourdrinier. Recirculation is desirable since the required exhaust volume is usually less than the volume of air supplied through a vapor absorption system, and if only the required exhaust volume were handled the hood would be under pressure which would not be desirable. Therefore, a difference between the exhausf and supply volumes to maintain a negative pressure under the hood can be recirculated at all times. In addition to this, additional air can be recirculated up to 100% which will result in steam savings. I know of one instance where recirculation equipment was installed on a dryer making approximately 30 tons of paper per day where the steam saving amounted to 2450 lb. of steam per hour. In my opinion the drying capacity of a machine is not affected by recirculation except perhaps an increase might be effected by the use of higher temperatures due to recirculation.

30. Q—*Is there any satisfactory alternative to "graduated drying," these graduations being expressed as an increase in steam pressure per dryer, or per group of driers, or in equivalent sheet temperature of moisture from wet to dry end?*
A—Slack off drier felts at wet end or take off the drier felts on the first 6, 7, or 8 driers. Maybe radiant heat can be used to make the first drier similar to normal fourth drier.

31. Q—*Velocity steam would appear to have certain advantageous factors such as increased steam velocity and rapid pressure fluctuations within the driers, both of which could increase the drying rate at the same steam pressure and sheet temperatures, etc. Is it generally confirmed in actual practice on up-to-date drier systems?*
A—It is hard to believe that the pressure inside the drier could be fluctuated rapidly enough to have any advantage. Likewise the steam velocity cannot be increased or used to advantage. If it is high momentarily it is reduced in like amount during other periods.

WELCOME

Southern Pulp and Paper Manufacturer extends a cordial welcome to its new contemporary—TAPPI Magazine—and wishes it success in its task of dissemination of scientific and technical knowledge to the Members of the Technical Association of the Pulp and Paper Industry in the complex field of pulp, paper, and paperboard product and process development.

Southern Pulp and Paper Manufacturer, a monthly also, publishes accurate news of Mills, Mill Men, and the Application of Technical and Scientific Developments to pulp, paper, and paperboard manufacturing.

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Vincent F. Waters, Editor

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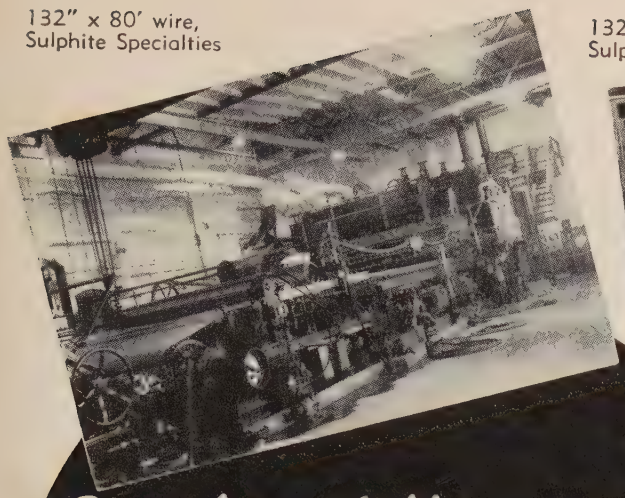

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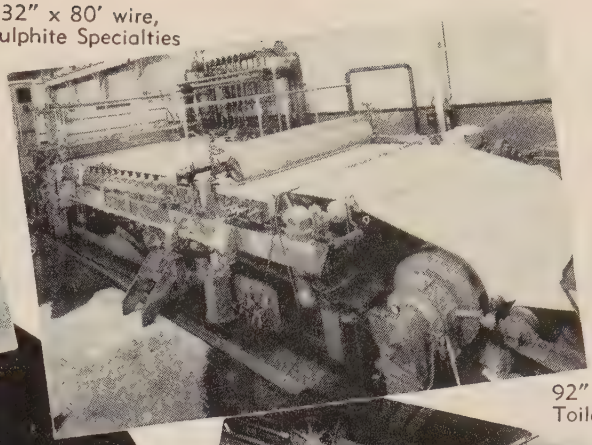

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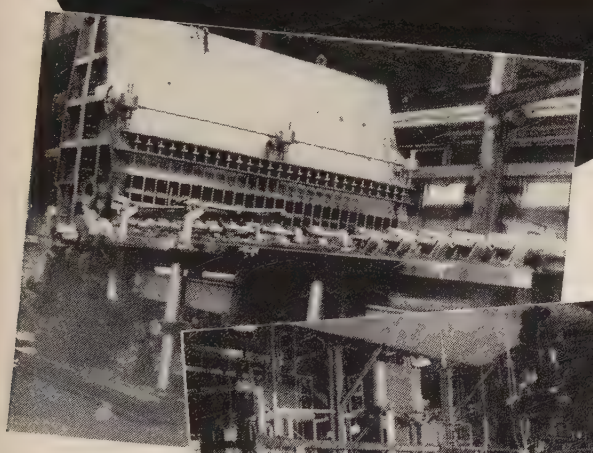

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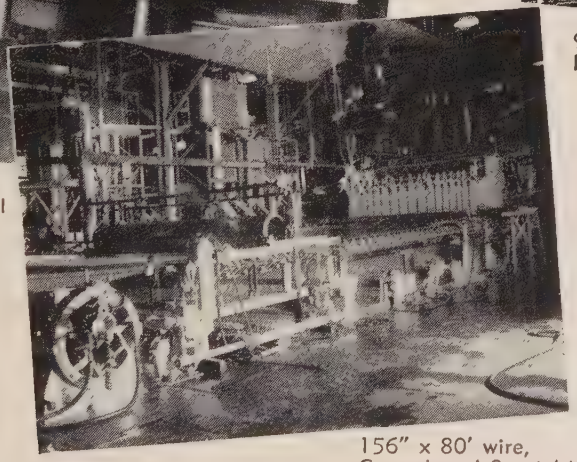

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The TAPPI 1948 Medal Award

The following presentation address and medalist's response are published in this issue to complete the record of a meritorious event. At the 1948 annual meeting of the Association the TAPPI medal presentation was scheduled to be a major event during the annual luncheon. On that occasion the medal was to have been presented to Dr. Emil Heuser by Dr. Harry F. Lewis of the Institute of Paper Chemistry on behalf of the Association.

Prior to the annual meeting Dr. Heuser retired as a member of the Institute staff and went to live in California. Consequently, the medal presentation ceremony was postponed. The TAPPI Pacific Section was commissioned to arrange for the presentation and as a result the medal was presented at a dinner party in Los Angeles to Dr. Heuser by H. A. Des Marais, a member of the Pacific Section.

Because of the importance of Dr. Heuser's great contributions to the technical advancement of the pulp and paper industry the originally scheduled presentation address and response are herewith published for the record. These remarks by the following two gentlemen have not been held since last February but were recently written at the request of the Association Secretary.

MEDAL PRESENTATION ADDRESS BY DR. LEWIS

It is my pleasure to present the TAPPI medalist for 1948, Dr. Emil Heuser, Emeritus member of the staff of The Institute of Paper Chemistry.

The pattern generally followed by the person selected to present the medalist includes, first, a rather complete biographical sketch, showing the events and factors in his life which were responsible for his later success, following which comes a long list of his accomplishments, thus demonstrating the wisdom of the committee in their choice.

In the case of the 1948 medalist, neither of these is absolutely essential, for the staff of *Chemical and Engineering News*, in the March 8 issue of this year, has painted a rather vivid picture from life of "Dr. Cellulose," and, as far as technical accomplishments are concerned, there are very few technical men in the pulp, paper, or rayon industry who have not had occasion to refer to some one of the medalist's researches. The book "Cellulose Chemistry" is "must" reading for all those who would truly understand the characteristics of cellulose.

However, there are those who have not seen the *Chemical and Engineering News* article and, for them, I'll try to cover some of the high lights of Dr. Heuser's life. His academic training was received at the Technical University, Munich, the University of Graz, and the Technical University of Karlsruhe. From the *Chemical and Engineering News* story, we learn that he had been associated with the paper industry from childhood, for he grew up in Stralsund on the Baltic Sea in the shadows of the playing card factory of which his father was technical director. As a papermaker, he started in business at the bottom as a workman in the coating machinery works of F. Mueller at Potschappel, going from there to the rag mill of Gebrüder Laiblin in Würtemberg. His first chemical position was with the Altdamm Kraft Pulp Company in Pomerania. From this he progressed to the position of coating superintendent at the Zehlendorf mill in Berlin and then to the pulp and paper company of Steyrermühl in Austria where he was chief chemist. In the year 1912, he received a call from, and became the director of the Institute of Cellulose Chemistry at the Technical University of Darmstadt and, while there, played an important part in training technical men for the pulp and paper industry of all the major countries. In 1923 he returned to industry as research director of the rayon company Vereinigte Glanzstoff, A.-G., near Berlin, and initiated his studies in the viscose and rayon field. After three years he left Germany for Canada where he established the famous research laboratory of the Canadian International Paper Company at Hawkesbury. In 1938 he joined the staff of The Institute of Paper Chemistry.

While at the Institute, he taught cellulose chemistry to students and staff alike, by formal lecture, seminar, student thesis committees, and in project conferences. In addition, he contributed extensively from his knowledge and experience to the projects of the Institute and its cooperators. Knowledge with him was something to be shared freely and with anyone who needed it—not something to store away to be dispensed grudgingly. Another of his outstanding characteristics was his eagerness to learn—he was a good listener.

Dr. Heuser's activities as an author are well known. His textbook, "Cellulose Chemistry," was first published in 1921, and two years later a second edition was printed; this was translated into English by C. J. West and G. J. Esselen, Jr. The translators acknowledged the help given by L. E. Wise in reading and critizing the manuscript. Little did Dr. Heuser realize back in 1924 that two of the three men to cooperate with him on the English edition of his book would turn up some fifteen years later as his colleagues on the staff of The Institute of Paper Chemistry. This second edition was translated into Russian and was followed in 1927 by a third German edition. In 1944 Dr. Heuser published his greatly enlarged "Chemistry of Cellulose." In addition, during the twenties he founded the journal *Cellulosechemie* and was editor of the technical section of *Der Papierfabrikant*. He was the chief editor of a series of books entitled "Technik und Praxis Der Papierfabrikation."

The article in *Chemical and Engineering News* lists among his technical accomplishments the development of the idea that celluloses from all known sources have identical molecular structures when freed from their noncellulosic impurities. To-day we take this more or less for granted, but twenty years ago this was not the case. If we were to select the field in which his researches have been the most beneficial, it would probably be that one dealing with the development of purified pulps for use in the manufacture of cellulose derivatives and rayon. Among his scientific activities at the Institute, we might list his studies of the photochemical degration of cellulose, the relation between the distribution of molecular weights and the physical properties of various cellulose fibers, and of the modification of the properties of cellulose fibers by partial conversion into cellulose derivatives, to list just a few. In addition to his work on cellulose, he has been interested over the years in the properties of hemicelluloses, lignin, and many other related materials. Members of our staff have had the experience of developing a new idea, only to find on checking the literature that the same idea had been suggested by Dr. Heuser years earlier.

(continued on page 60 A)

CLINTON

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CLINTON, IOWA

(continued from page 58 A)

Those rather well-known characteristics and accomplishments of Emil Heuser furnish the pattern by which he is known to the world at large. To describe the "Dr. Cellulose" we like and admire so much at The Institute of Paper Chemistry calls for more than a listing of his technical accomplishments, for he is a curious combination of the scientist, the artist, and the general good fellow. In his youth he devoted much time to studying the arts, and in this environment he met and married the portrait artist who has been the center of the Heuser family circle ever since. His early interest in painting has never diminished, as the walls of his house and office in Appleton testified. He loves music. At Lawrence College, concerts by renowned musicians and tyros alike were always graced by the presence of the Heusers. Many a young musician was encouraged along the way by their interest. The word "gemütlich" completely describes their life. At the same time, as both students and assistants can testify, the Professor could be peppery, particularly at a shabby piece of work, whether it was in science or in art. In his own work he held himself up to nothing but the best. In his writings he would shape and reshape a phrase to capture the most effective way of describing the idea. His lectures were models of arrangements and of English.

Naturally a man of this type could not be happy unless he were active in the broader scientific associations of his community. He was a member of the Northeast Wisconsin Section of the American Chemical Society of which he is a past-distinguished president. Following the presentation of the technical address at the meetings of the society, whenever the discussion seemed to lag, Dr. Heuser would bring it back into focus by some well-chosen question or reference to an application; whether the subject dealt with cellulose or rare metals made very little difference to him. His broad background and interests always seemed to reach out to the point of common understanding which is so essential to a good discussion.

TAPPI honored Dr. Heuser in presenting him with the TAPPI medal for 1948, and Dr. Heuser, in turn, honored TAPPI as a worthy recipient of the medal. His associates at the Institute all join me in extending our congratulations and best wishes on this occasion of recognition of his services to the pulp and paper industry.

RESPONSE BY EMIL HEUSER

I am very grateful to Dr. Lewis for his fine and cordial comments. How deeply I appreciate the honor bestowed upon me by TAPPI, I have expressed on various occasions. Once more, I wish to say that the TAPPI medal award fills me with pride and gratitude.

Of the various periods of my activities which Dr. Lewis has mentioned, I particularly like to remember those during which I had an opportunity to apply scientific principles to technical processes, so as to give justification to the empirical and, furthermore, to see how procedures and reactions, worked out in the small scale in the laboratory, would operate in the large scale plant.

When I had been lucky enough to get some first hand knowledge of how rayon was made commercially and when research in this field had uncovered some, although still rather vague, ideas of what the essential characteristics should be that would make a good rayon pulp, I was given an excellent opportunity to prove or disprove such ideas during my association with the Canadian International Paper Company. Those concerned with the manufacture of rayon pulp had just begun to realize that the pulp's viscosity was one of its foremost characteristics, and that a uniform viscosity was even more important than other characteristics. However, there still existed considerable difficulty in producing the desired viscosity and in keeping it reasonably uniform. Little was known about the relations between the variables which are operative during the pulping, bleaching, and purification steps and which all contribute, although to a different extent, to the viscosity of the final product. It was here where assistance was needed. So, the research laboratory went to work in an attempt to throw as much light as possible upon these relations.

As a result of numerous experimental studies, it was recognized that—speaking generally—the viscosity and, for that matter, also the other main characteristics of a pulp are produced during the pulping operation and that attempts to impart to the pulp the desired viscosity during the bleaching and purification steps, i.e., with disregard to what happened during pulping, are doomed to failure. Likewise, it was recognized that the purpose of these two latter steps should be essentially confined to producing brightness under as mild conditions as possible, so as to maintain the characteristics which had been aimed at and created in the digester. By adhering to this principle, the improvements in alpha-cellulose, copper number, etc., which the bleached pulp showed as compared with the unbleached, were quasi automatically obtained.

Of the various factors which operate during the pulping step to lay down the pulp's viscosity, it is the maximum temperature and the length of time this temperature is maintained in the digester which were found to be the most decisive ones. On the same basis, the time allowed for reducing the pressure before blowing—the blow back time—proved to be an efficient means of adjusting the viscosity to values somewhat above or below those which existed at the end of the maximum temperature period. A general fixation of the viscosity was possible by varying the combined SO_2 content of the cooking acid. Thus, the buffering action of a high combined was used to minimize hydrolytic effects, that is, to keep the viscosity on the high side, and vice-versa. However, in order to utilize and control these variables, strictest consideration had to be given to their relations to each other.

Of course, today all these things and many more are common knowledge. The same is true as far as the other pulp characteristics are concerned. In this respect it is interesting to recall the fact that some twenty years ago, these characteristics were quite a bit below those which are required to-day. Thus, an alpha-cellulose content of about 88% was then accepted, whereas, when I left Canada in 1938, it had to be at least 90%, and to-day, it has climbed to 91 to 92%, and the tendency is still upward. To most, this may appear to be not a big difference. But those who were and are actively engaged in rayon pulpmaking know how much effort is required for increasing the alpha-cellulose content even only a few tenths of one percent without upsetting the viscosity.

To-day, the pulp manufacturer knows not only how to produce a high alpha-cellulose and a correspondingly low noncellulosic carbohydrate content, but also how to fulfill the other requirements—that is, copper number, ash, calcium, iron and other metals, as well as resin, to be as low as possible and, in addition, to impart to the pulp those physical characteristics of adsorption, swelling, etc., which are so important for its good behavior when it passes through the various steps of conversion. However, it is good sometimes to remember that these accomplishments are the outcome of painstaking research, carried out over many years by a considerable number of men.

It was a lucky coincidence that when the ground was being laid for the selection of suitable cooking methods for rayon pulp, the technique of pulp bleaching took a remarkable upswing. Although one-stage bleaching—with all its draw-

(continued on page 62 A)

To make PAPER, you need STEEL

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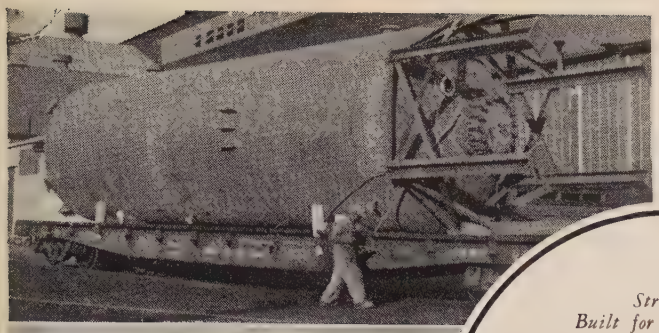
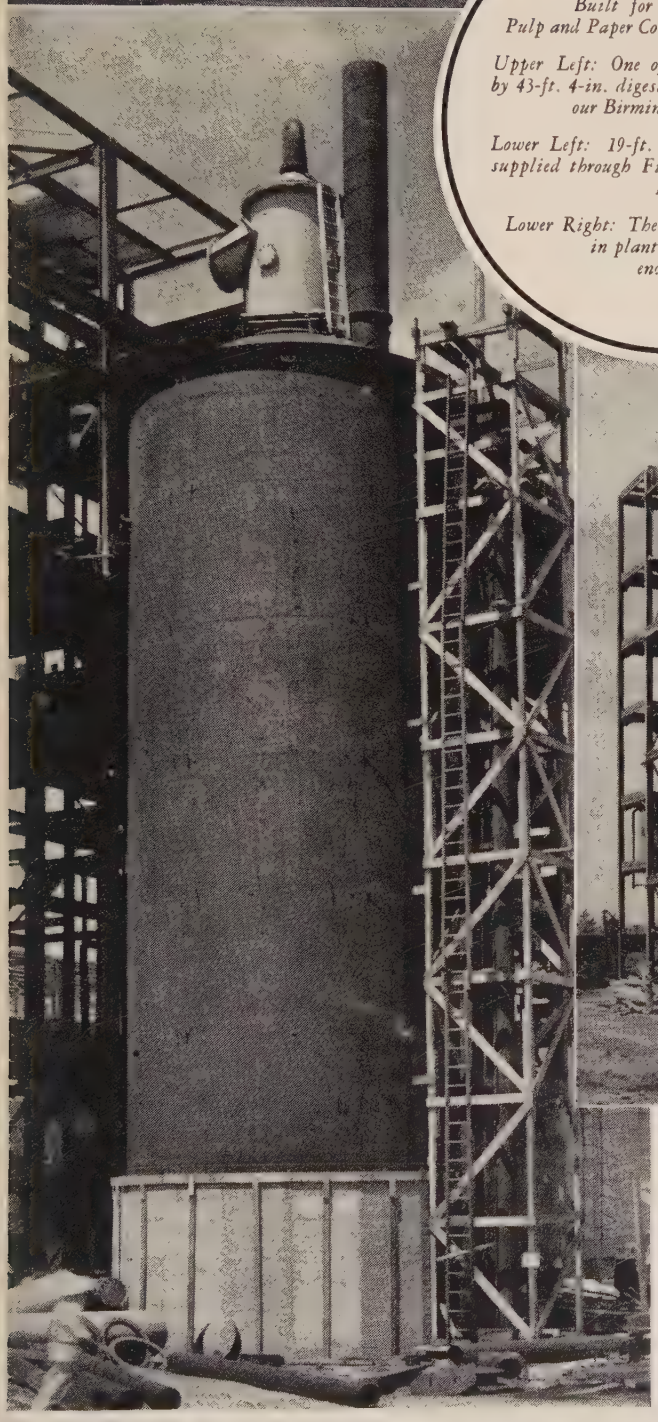


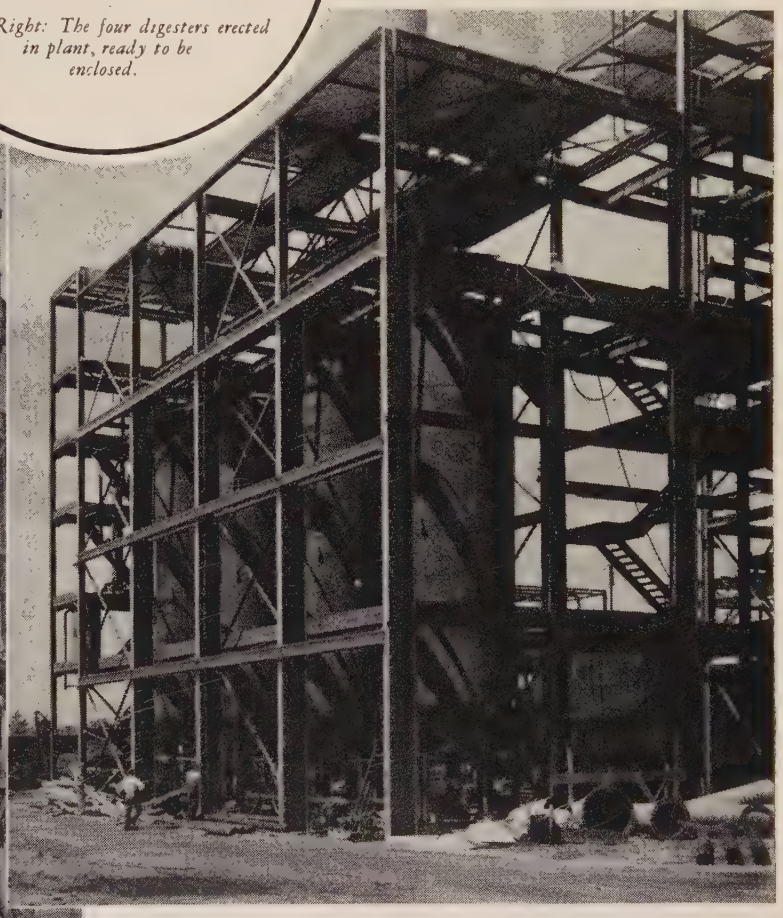
Structures Built for the Hudson Pulp and Paper Company, Palatka, Fla.

Upper Left: One of the four 10-ft. 9-in. by 43-ft. 4-in. digesters being shipped from our Birmingham plant.

Lower Left: 19-ft. by 45-ft. accumulator supplied through Fibre Making Processes, Inc.

Lower Right: The four digesters erected in plant, ready to be enclosed.





Digesters, accumulators, diffusers—these are some of the Horton structures which are being specified in modern pulp and paper mills. Our complete services of designing, fabricating and erecting are performed by experienced engineers and skilled workmen in our shops and the field. Stress-relieving and x-raying to meet code requirements are included in our regular services.

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(continued from page 60 A)

backs—was still the most widely practiced system when I came to Canada in 1926, multiple stage bleaching had already made considerable strides. As is well known, C. B. Thorne of the Canadian International Paper Company was one of its pioneers, particularly in its high consistency and continuous system modifications. Thorne had just developed his bleaching tower. With two of these, high-consistency pulp suspensions were bleached continuously in two stages, using hypochlorite solutions in both, and washing and reconcentrating the stock between the stages. Subsequently—for reasons of better control and facilitating the making of adjustments—the bleaching of rayon pulp became partly discontinuous, the second stage being carried out in a bellmer and at a lower consistency than in the tower.

While these developments, which were chiefly concerned with the solution of the various mechanical problems, were in progress in the engineering offices and the plants, the research laboratories were busy with studying the chemical reactions involved. Thus, we became acquainted with the influence of the various factors, as consistency, temperature, hydrogen ion concentration, etc., upon the course of these reactions and upon the intermediate and final characteristics of the pulp so produced. And, thus we learned how to make use of, and to change the variables, in the multiple stage system for producing the best results. Valuable practical information was also acquired as regards the use of alkali instead of water and of various types of alkalies when treating the pulp between the stages, as a means of producing a more purified pulp. But the most welcome progress came with the revival of the use of chlorine, as such, as a bleaching agent.

This revival had been sponsored about 1913 by De Vains and Petersen (U. S. Patent, 1914), but did not seriously interest those concerned with the bleaching of pulp until the early twenties. In making use of chlorine as a bleaching agent in the Kipawa and Hawkesbury mills of the Canadian International Paper Co., benefit was derived from the development which in the early twenties had resulted from the independent studies of Opfermann and of Niethammer and which had demonstrated the advantages of giving the unbleached pulp considerably less than the total bleach demand in the form of chlorine and employing the balance in the form of hypochlorite, with an alkaline extraction after the chlorine treatment. The main outcome of these studies was that the bleaching process had now actually become a two-stage affair, and the application of this knowledge, together with that derived from further studies of the alkaline purification step, to large-scale bleaching, first of rayon and then of paper pulp, proved to be quite successful, although not until the mechanical headaches, of which there were many and painful ones, had been overcome.

What I have said on previous occasions, I wish to stress again, namely, that the research work we did would have been of little use, if it had not been for the excellent cooperation from those who were, and partly still are, responsible for the large scale operations in the mills. Without their knowledge, experience and skill, their understanding and enthusiasm, we would have accomplished very little, indeed.

During my activities in Canada, I often wished I would find leisure enough to sit down once in a while and to take account of the technical development, to "sift the chaff from the wheat," to become more thoroughly impressed by, and thus to understand more fully, what mistakes we had made and why, and how to avoid them in the future.

At the same time, I felt I was somewhat losing track of the theoretical developments which took place in the cellulose field. With the speed with which technical progress was moving ahead; with the pressure which such speed naturally exerted upon the work in the laboratory; with the increase in duties and responsibilities—there simply was not enough time left for such leisurely activities and for the concentration required for making such contemplation constructive. What I was longing for, I found years later so adequately expressed by W. S. Learned of the Carnegie Foundation for the Advancement of Teaching when he said (Ann. Report 1942–43, p. 31):

> "The getting of knowledge is the means to an end. It is the filling of reservoirs for future use. It is the foundation for future wisdom. Day-to-day knowledge, therefore, will not serve. Knowledge must be deliberately matured and digested for permanent possession."

Thus, the desire of returning to academic life became stronger as time went on. On the other hand, I did not like the thought of becoming too much detached from the industrial development. Hence, when the Institute of Paper Chemistry seemed to offer the thing I was looking for—one may call it a synthesis of fundamental and applied research—with the added chances of teaching and literary activity, I was only too glad to join its staff.

I do not think that I should add anything to what Dr. Lewis has said about the time of my association with the Institute—except restating that I have thoroughly enjoyed these last ten years, namely, the work with the students, the association with so many excellent and capable men of the industry, the working together and exchange of thoughts with my colleagues, and the opportunity of reviewing the standing of what we know to-day of this shrewish, elusive, and yet so attractive thing called cellulose.

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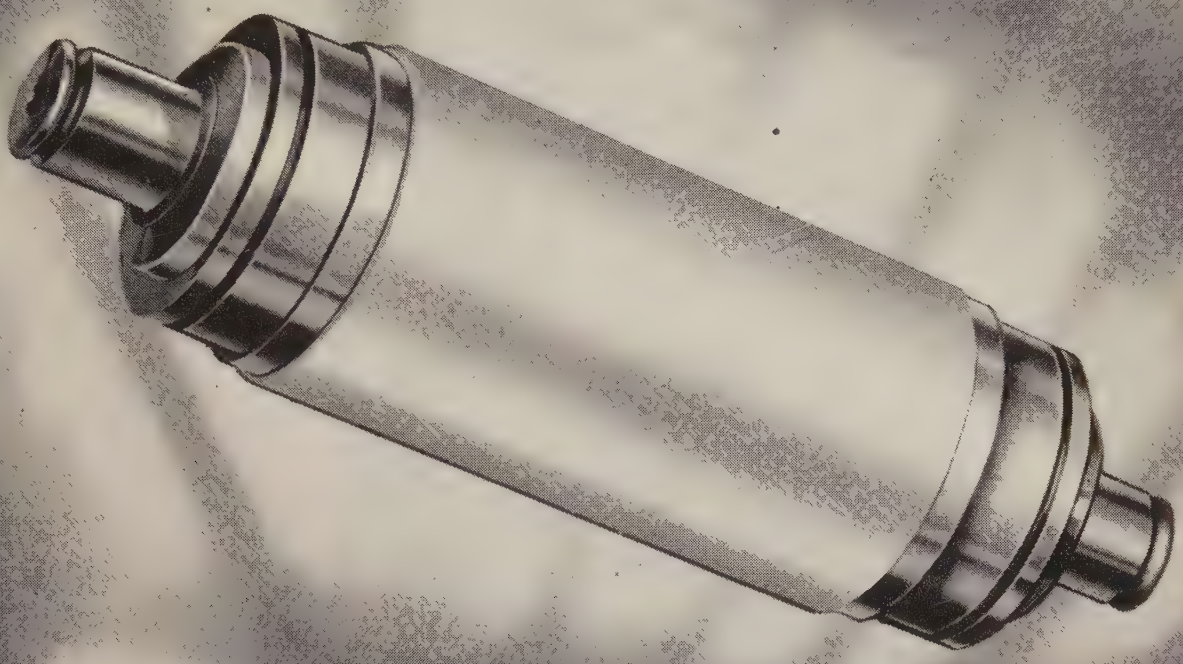

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PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

The Executive Committee of the Technical Association of the Pulp and Paper Industry has elected the following to membership:

Geoffrey Beall, Statistician, Preston Laboratories, Butler, Pa., a 1938 graduate of the University of London with a Ph.D. degree.

Kenneth Bowers, President and Chief Engineer, Glens Falls Laboratory, Inc., Glens Falls, N. Y. Attended Northeastern University.

Harrison G. Burbidge, Junior Chemist, Provincial Paper Ltd., Port Arthur, Ont., a 1944 graduate of Queens University.

Roger A. Calsibet, Assistant Division Manager, Bakelite Corp., New York, N. Y., a 1940 graduate of Princeton University.

J. Andrew Clark, Sales Manager, Wallerstein Co., Inc., New York, N. Y., a 1917 graduate of Rhode Island State College.

Joseph P. Early, Assistant Chemist, International Paper Co., Niagara Falls, N. Y., a 1944 graduate of the New York State College of Forestry.

John M. Fisher, Chemical Engineer, The Manistique Pulp & Paper Co., Manistique, Mich., a 1944 graduate of Louisiana State University, with a B.S. degree in Mechanical Engineering; and a 1947 graduate of Purdue University with a B.S. degree in Chemical Engineering.

William A. Hermanson, Technical Director, Technical Papers Corp., and William A. Hermanson & Co., Boston, Mass., a 1916 graduate of Harvard University.

H. Maxwell Hughson, Research Engineer, Provincial Paper Ltd., Port Arthur, Ont., a 1945 graduate of the University of Toronto.

Thomas M. James, Jr., Service Engineer, The Flox Co., Inc., Minneapolis, Minn. Attended the University of Minnesota.

Wallace W. Klug, District Manager, Reichhold Chemicals, Inc., Milwaukee, Wis., a 1916 graduate of Kentucky Military Institute.

Ralph M. Lapham, Director of Research, Glens Falls Laboratory, Inc., Glens Falls, N. Y.

John T. Moss, Sales Engineer, The Pusey & Jones Corp., Wilmington, Del., a 1934 graduate of Purdue University.

Edward A. Murphy, Superintendent of Paper Mill, St. Regis Paper Co., Oswego, N. Y.

George B. Nicholson, Jr., Research Engineer, Dilts Machine Works, Fulton, N. Y., a 1941 graduate of the New York State College of Forestry.

Richard V. Osborn, Technical Director, Imperial Mill, St. Regis Paper Co., Kalamazoo, Mich., a 1946 graduate of Clarkson College of Technology.

Edward B. Osborne, Technical Service Engineer, B. F. Goodrich Chemical Co., Cleveland, Ohio, a 1941 graduate of Illinois College, with an M.S. degree from the University of Wisconsin in 1943.

Robert Schulein, 1150 Park Avenue, New York, N. Y., a 1948 graduate of the New York State College of Forestry.

J. R. Sen, Engineer, Bengal Paper Mills, Raniganj, West Bengal, India, a 1935 graduate of Kanchrapara Technical School.

William Moore Springer, Vice-President in Charge of Research, Bristol-Myers Co., Hillside, N. J., a 1915 graduate of Columbia University.

Cyril J. Straka, Laboratory Supervisor, Westinghouse Electric Corp., Micarta Division, Trafford, Pa.

Dean Sutton, Agent, Paris Office, Gaillet & Hartig Co., Inc., New York, N. Y., a 1931 graduate of the University of Notre Dame.

Lester J. Tarbell, Assistant to Vice-President, Bird & Son., Inc., East Walpole, Mass., a 1938 graduate of the University of Maine.

James S. Thornton, Sales Engineer, Downingtown Manufacturing Co., Downingtown, Pa., a 1941 graduate of Massachusetts Institute of Technology.

Claire Turner, General Superintendent, Warrensburg Pulp & Paper Corp., Warrensburg, N. Y.

Fred A. Wolf, President, Coatings and Chemicals Corp., Chicago, Ill., a 1939 graduate of the University of Illinois.

TAPPI Directory Changes

John R. Stephenson, formerly manager of the Waloomsack Paper Mills, is now a member of the firm of Baxter-Stephenson, Consulting Engineers, Middletown, Ohio.

Harold T. Randles, chemist for the St. Regis Paper Co., has been transferred from Deferiet, N. Y., to Tacoma, Wash.

Paul V. Greenfield, formerly student at the Inst. Paper Chemistry, is now in the Research and Production Section, Ethyl Cellulose Division, Dow Chemical Co., Midland, Mich.

Fred S. Hanson, formerly research chemist, Kimberly-Clark Corp., is now asst. professor of chemical engineering, New Mexico A. & M. College, State College, N. M.

John O. Edwards, formerly student, Inst. Paper Chemistry, is now in the chemistry department, University of Wisconsin, Madison, Wis.

John E. Bauman is now asst. manager, Paper Container Mfg. Co., Chicago, Ill.

Lewis K. Burnett, formerly of the Curtis Publishing Co., is now manager of quality control, Ohio Boxboard Co., Rittman, Ohio.

Edward W. Murphy, formerly of the H. D. Catty Corp., is now asst. superintendent, Milprint, Inc., Milwaukee, Wis.

Lloyd Lang, formerly development engineer with the Crossett Paper Mills, is now with the Green Bay Paper and Pulp Co., Green Bay, Wis.

John B. Calkin, formerly of the Union Bag & Paper Corp., is now consultant to the pulp and paper and chemical process industries, 500 Fifth Ave., New York 18, N. Y.

Ralph J. Benes, Jr., is now asst. steam superintendent, International Paper Co., N. Tonawanda, N. Y.

C. R. P. Cash, formerly of the Brown Co., is now superintendent of the board mill, Fibreboard Products, Inc., Antioch, Calif.

Russell V. Knapp, formerly of the Bailey Meter Co., is now power engineer, Mosinee Paper Mills, Mosinee, Wis.

John D. McCrystle, formerly with Johnson & Johnson, is now asst. to the president, The Upson Co., Lockport, N. Y.

Lawrence L. Clapp is now technical director, Florida Pulp & Paper Co., Pensacola, Fla.

Richard S. Buckley, formerly with the Fernstrom Paper Mills, is now chief chemist, Rochester Paper Co., Rochester, Mich.

Hans Gottstein-Glynn, formerly of Thomas Owen & Co. Ltd., is now director of The Anglo-Continental Pulp and Trading Co. Ltd., London, Eng.

Fred S. Van Voorhis is now technical engineer, John A. Manning Paper Co., Troy, N. Y.

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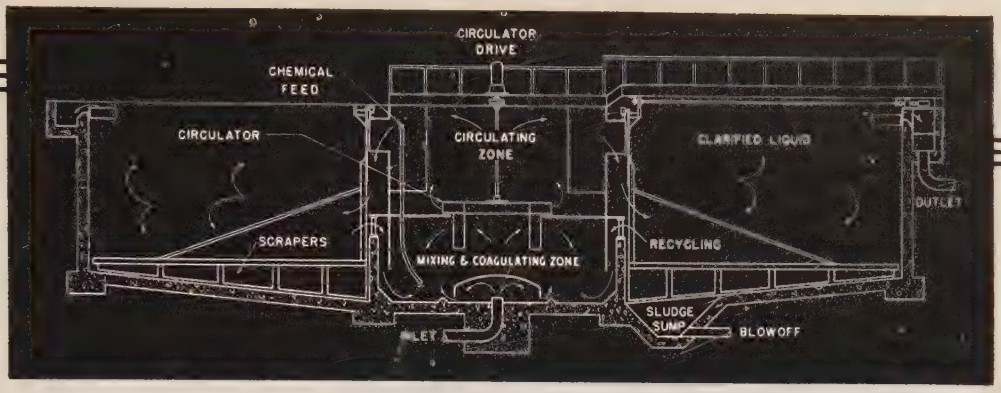
NEW White Water Treatment



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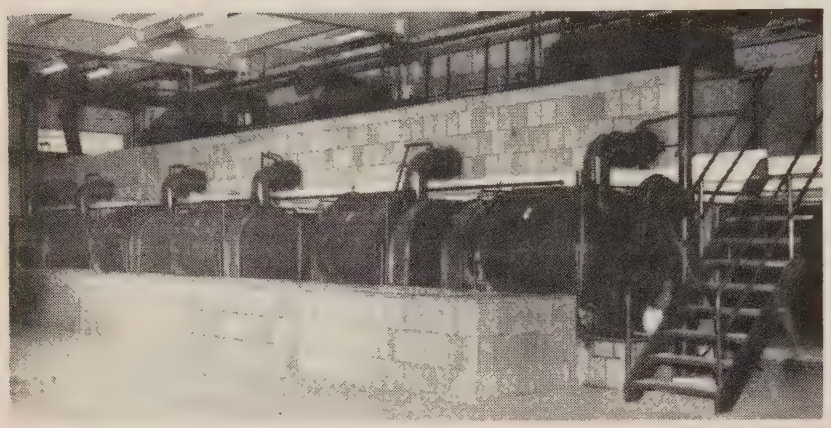

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(continued from page 64 A)

Edgar W. Pitt is now vice president, Central Paper Co., Muskegon, Mich.

Paul M. Schaffrath, formerly of the Howard Paper Mills, Inc., has joined the staff of the Pulp and Paper Dept., New York State College of Forestry, Syracuse, N. Y.

Kenneth E. Glidden, formerly of the staff of the Institute of Paper Chemistry, is now director of research, The Celon Co., 2034 Penna Ave., Madison, Wis.

John Studeny, formerly research chemist, American Cyanamid Co., is now with the Hammermill Paper Co., Erie, Pa.

H. Ainsworth Harrison is now technical director for Cooke & Nuttall, Ltd., and the Associated Paper Mills, Ltd., Norwich, Lancs., and London, Eng.

William M. Barrett is now pulp salesman, The Mead Sales Co., Chicago, Ill.

A. Sensor Ryan, formerly of the Vermont Bur. Industrial Research, is on the staff of the chemistry and chemical engineering department, University of Washington, Seattle, Wash.

J. E. Goodwillie, vice president, has succeeded Harry C. Moore as official representative of the Beloit Iron Works, Beloit, Wis., in the Technical Association.

Milan Boax, general manager, has succeeded A. H. Hansen (deceased) as corporate representative of the Northern Paper Mills, Green Bay, Wis., in the Technical Association.

Kenneth L. Moses has succeeded Lyman Beeman as corporate representative of the St. Regis Paper Co., New York, N. Y., in the Technical Association.

E. J. Manion, Eastern Division Manager, has succeeded H. L. Dunham as official representative of the Dicalite Div., Great Lakes Carbon Co., New York, N. Y., in the Technical Association.

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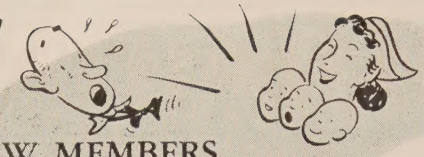
Calendar of TAPPI Meetings

NATIONAL

Annual Meeting, Commodore Hotel, New York, N. Y., February 21–24, 1949.
Paper Coating Conference, Pantlind Hotel, Grand Rapids, Mich., April 25–28, 1949.
General Fall Meeting, Multnomah Hotel, Portland, Ore., September 11–15, 1949.
Fourth Engineering Conference of the Pulp and Paper Industry, Statler Hotel, Boston, Mass., October 31, November 1–3, 1949.

LOCAL SECTIONS

CHICAGO SECTION: Chicago Bar Association, Chicago, Ill.
February 21, 1949; March 21, 1949; April 18, 1949.
DELAWARE VALLEY SECTION: Engineers Club, Philadelphia, Pa.
January 27, 1949; March 24, 1949; April 28, 1949; and May 26, 1949.
EMPIRE STATE SECTION:
Western New York Group: February 9, 1949, at North Tonawanda, N. Y., co-sponsored by the International Paper Company and Robert Gair Co. Tour of mills, followed by dinner meeting.
April 13, 1949, at Erie, Pa., sponsored by the Hammermill Paper Co. Tour of mill, followed by dinner meeting.
Metropolitan Group: Fraunces Tavern, New York City
Meetings on first Tuesday of month.
KALAMAZOO VALLEY SECTION: Park American and Columbia Hotels, Kalamazoo, Mich.
Meetings on second Tuesday of month.
LAKE STATES SECTION: American Legion Club House, Appleton, Wis.
February 8, 1949—Forest Products Laboratory Program
March 8, 1949—Stock Preparation
April 12, 1949—Marathon's Canadian Operations
NEW ENGLAND SECTION:
Meetings usually held on the third Friday each month, usually at the Roger Smith Hotel, Holyoke, Mass., unless otherwise announced.
OHIO SECTION: Manchester Hotel, Middletown, Ohio
February 15, 1949—"Calender Finishes"
March 10, 1949—"Paper Coating"
PACIFIC SECTION:
April 8, 1949, Longview, Wash.—Shibley Award Contest
PAPERMAKERS & ASSOCIATES OF SO. CALIF.:
January 20, 1949—Ivan's Cafe, Lynwood, Calif. "Electric Paper Machine Drives"



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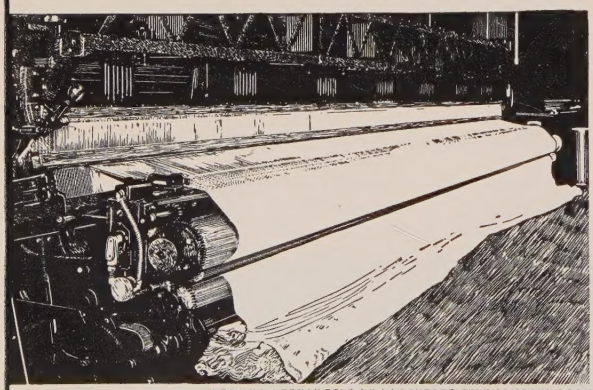

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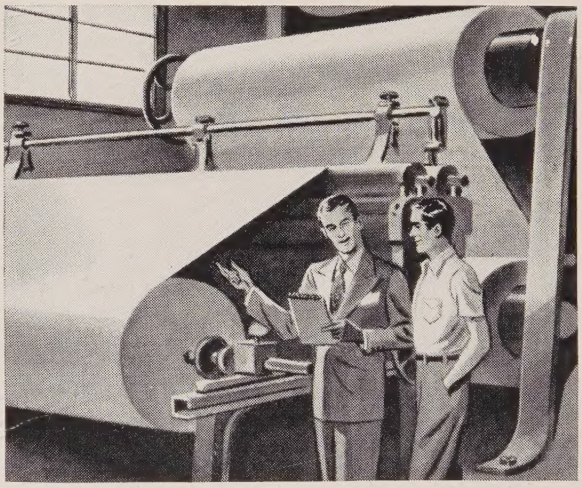

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